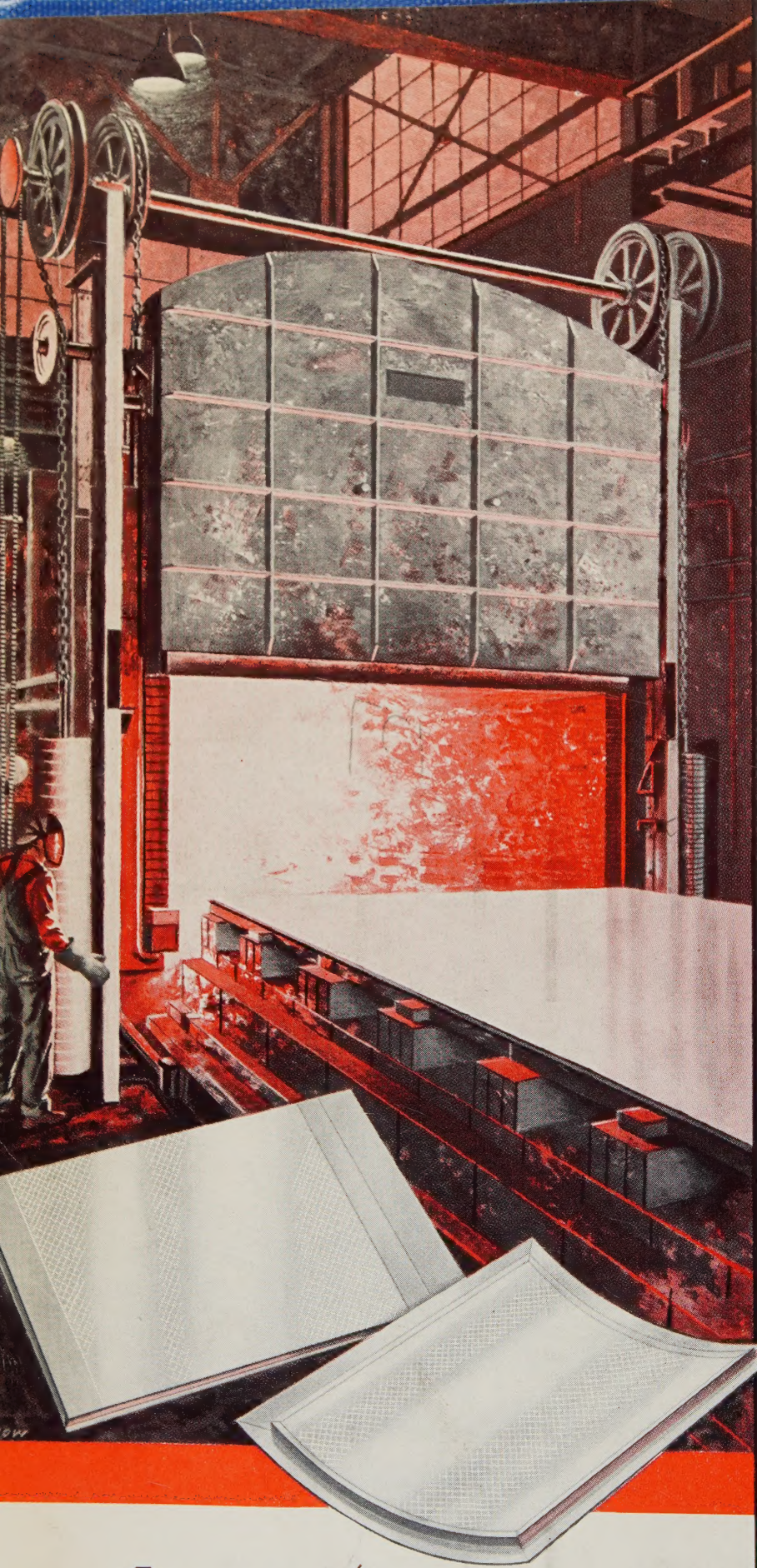
The magazine of aerospace technology / JULY 1959

space/aeronautics

formerly Aviation Age

FIRST DETAILS:
MERCURY CAPSULE ENVIRONMENTAL SYSTEM

A CONOVER-MAST PUBLICATION



From a giant new furnace . . .

AVCOMB®
for the Structures of Tomorrow

In just a few weeks, Avco's Nashville Division will have in operation one of largest car-bottom, gas-fired box furna in the country . . . to produce *Avcomb*, stainless-steel honeycomb structures fo missiles, space vehicles and high-speed military aircraft like the B-70 and F-1

In this furnace the Nashville Division will make both contoured and flat pan up to six feet wide and 25 feet long.

Already two smaller furnaces are turning out small panels for the high-speed aircraft of the 1960's, as well as other important components requiring high resistance to heat and a very high strength-to-weight ratio (prime characteristics of *Avcomb*). In a few more weeks, the Nashville Division wil announce even more production capaci for *Avcomb* through new and less costly processes than those now generally known to industry.

Both the Nashville Division's engineers and its management believe that *Avcomb* stainless-steel honeycomb will be to the aircraft of the future what aluminum is to today's aircraft. And li aluminum in its early years, *Avcomb* will find its way into many new, and as yet unforeseen, applications.

Anticipating *Avcomb's* prospects, Nashville Division engineering already is looking into new and challenging applications for its complete design, too and build capability for stainless-steel honeycomb. Several such applications now are under investigation. They rang over a broad area, from armorclad structures for military vehicles to air-droppable buoys.

For more information about *Avcomb* and the Nashville Division's design, tool, and build capability, write: Marketing Manager-Structures, Dept. C Nashville Division, Avco Corporation, Nashville, Tenn.

Avco / Nashville

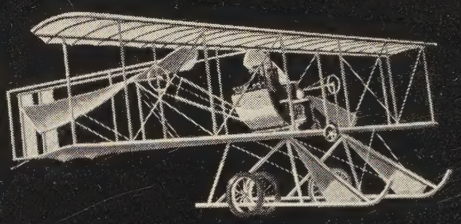
Unusual career opportunities for qualified scientists and engineers . . . write Avco/Nashville today.

Pardon our pride—but we're celebrating

50 years of "FIRSTS"

in the aviation industry!

1909



First pneumatic airplane tire, built by Goodyear to replace sled runners used by Wright brothers.

1959

First in aviation tire production and sales every year for half a century—on the *first* of America's finest jet-liners. More jets and prop-jets now in service land on Goodyear aircraft tires than on any other kind. In fact, there are more Goodyear tires, wheels and brakes in commercial aviation service than all other makes combined.

Other Famous "Firsts" by Goodyear Aviation Products

FIRST low-pressure pneumatic airplane tire—the Airwheel.

FIRST brake designed specifically for aircraft.

FIRST fully automatic system of ice detection and ice elimination for aircraft.

FIRST tubeless tires specified for commercial airliners.

FIRST successful self-sealing fuel tank.

FIRST complete line of nylon cord tires for high-speed aircraft.

—and the best is yet to come!

***NEW DYNAMOMETER**—capable of speeds to 500 mph—will qualify tires for the highest-performance aircraft of the foreseeable future.

***NEW FABRIC REINFORCED TIRES AND RETREADS.** Goodyear is now qualified to retread jet airliner tires to new tire specifications.

***NEW DURABOND BALANCING** assures lasting adhesion of balancing compound *inside* aviation tire, perfect balance *outside*.

THE ABILITY TO ANTICIPATE the ever-changing needs of America's airlines has been the main factor in Goodyear's 50 years of aviation achievement. Now—as the industry shifts to jet power—Goodyear stands ready to meet the challenge of longer ground distances, faster landings, higher loads. We're anticipating these needs now—developing still more Goodyear "firsts" for tomorrow and far into the future.

Goodyear Aviation Products maintains the largest field service staff of its kind in the industry. These trained service representatives—strategically located throughout the nation—serve commercial airlines and commercial manufacturers wherever and whenever needed.

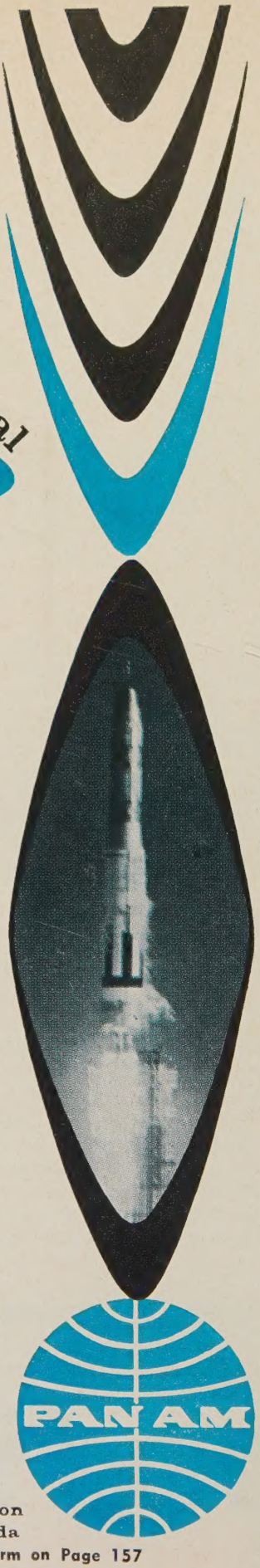
AVIATION PRODUCTS BY

GOODYEAR

Airwheel—T. M. The Goodyear Tire & Rubber Company, Akron, Ohio

Write in No. 1 on Reader Service Card

countdown: canaveral



One of our century's most significant events is the countdown at Cape Canaveral. Participation in the countdown, in the planning and preparation that precedes it, and in the test data collection and evaluation that follows, is one of the jobs of the Pan Am engineer.

Our Guided Missiles Range Division assists the Air Force in management, operation and maintenance of the 5000-mile Atlantic Missile Range. Thus each member of our technical staff has a unique opportunity to play an intimate, vital role in the nation's major missile test and space exploration activities.

[redacted]

For an investigation of your future in the space age with Pan Am, send a brief resume in confidence to Mr. J. B. Appledorn, Director of Technical Employment, Pan American World Airways, Inc., Patrick Air Force Base, Florida, Dept. T-6.

PAN AM

Guided Missiles Range Division
Patrick Air Force Base, Florida

Check Employment Inquiry Form on Page 157

space/aeronautics

Publisher
William G. Maass

Editor
Raldolph Hawthorne

Managing Editor
Englebert Kirchner

Associate Editor
Irwin Stambler ..... Dynamics, Materials, Structures, Production
Victor DeBiasi ..... Systems, Accessories, Ground Support
James Holahan ..... Electronics
Bernard Kovit ..... Electronics
Robert M. Loebelson .... Technical Management

Contributing Technical Editor
Kurt R. Stehling ..... Propulsion, Astronautics

Washington Bureau Chief
A. N. Wecksler..Government Policy

Editorial Assitant
Joan Bessel

Foreign Corresponding Editors
Denis Desoutter ..... England
Hans Kosman ..... Holland
Robert Roux ..... France
Walter P. Moser ..... Switzerland
Giorgio Apostolo ..... Italy

Art & Production
E. Carlton Arink ..... Art Director
David Burke..Associate Art Director
N. T. Gravin ..... Asst. Prod. Mgr.
Vivien L. Lorenz .... Prod. Superv.

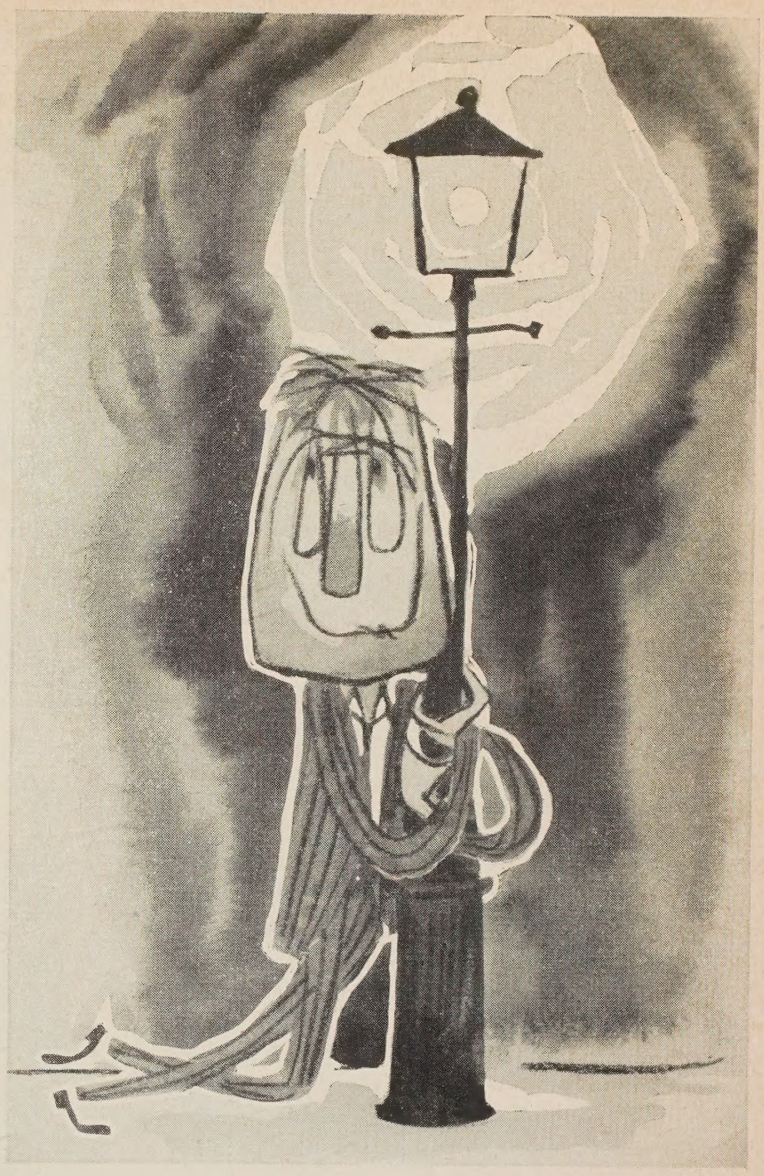
Business Staff
William Wessel .... Asst. Publisher
David W. Ewald .. Adv. Sales Mgr.
G. Peter O'Neill .... Regional Mgr.
M. E. Litz ..... New York Rep.
Robert Keegan ..... Regional Mgr.
Robert J. Reed .... Cleveland Mgr.
George J. Mehl .... Cleveland Rep.
Charles G. Paxson .. Midwest Mgr.
William D. Gullickson Midwest Representative
Dwight Jennett Pac. Coast Reg. Mgr.
Walter Greenwood Pac. Coast Reg. Mgr.
Maury Norrell..Pac. Coast Reg. Mgr.
Barend Broekman .. Mgr. Int. Adv.
Hy Sirota ..... Promotion Manager
Roy Ellison..Circulation Supervisor
Eileen Reardon..Mgr., Adv. Service

Editorial & Executive Offices
New York 17, N. Y., 205 E. 42nd St.
MUrray Hill 9-3250

Regional Offices
Washington 4, D.C., 869 National Press Bldg. NAtional 8-2773
Cleveland 15, Ohio, 190 Euclid Bldg. CHerry 1-7788
Chicago 11, Ill., 737 N. Michigan WHitehall 4-6612
Los Angeles 35, Calif., 864 S. Robertson Blvd. OLeander 5-9580
Amsterdam, Holland
47 De Lairessestraat, Tel.: 799014

Accepted as controlled circulation publication at Philadelphia, Pa., New York, N. Y.

Steady, there!



Because his motor control system is inadequate to "orbital" conditions, the happy fellow above may well feel more than a little "out of this world". His old familiar muscles are incapable of providing the precise, reliable control he needs.

So it is with the new generation of high-speed air and space vehicles. More and more, hydraulic servomechanisms are giving way to a variety of *hot gas actuator systems,* relatively insensitive to high ambient temperatures and in many ways ideally suited to such requirements as space-age vector and vernier control.

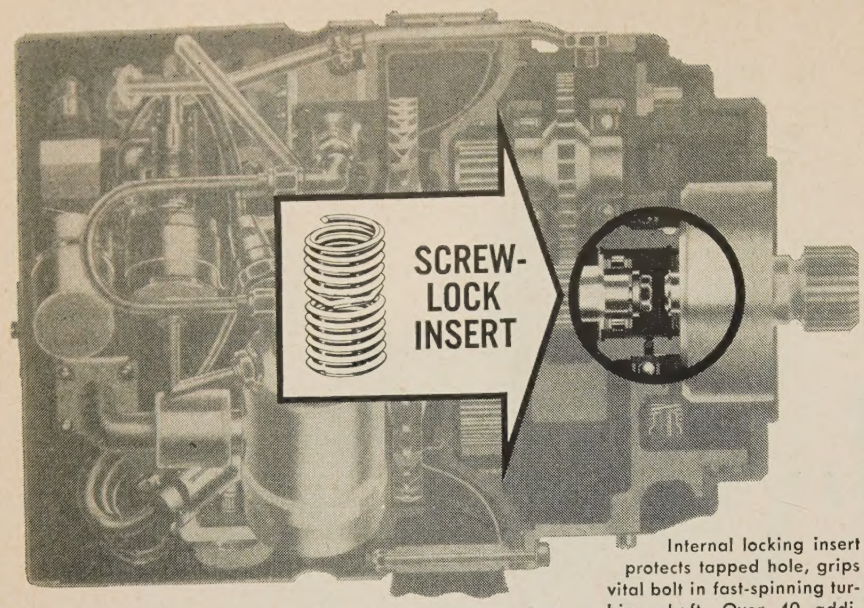
Chandler Evans has been conducting a number of research and development programs in the field of high-pressure pneumatics. As a result of its extensive feasibility studies, CECO is now prepared to discuss with you the merits of systems which feature the use of chemically generated gases derived from either solid or liquid propellants.

CHANDLER EVANS CORPORATION WEST HARTFORD 1, CONNECTICUT

For a new folder on CECO hot gas actuator systems, address your request to Department 49.

CECO
SYSTEMS
CONTROLS

Write in No. 3 on Reader Service Card at start of Product Preview Section



Internal locking insert protects tapped hole, grips vital bolt in fast-spinning turbine shaft. Over 40 additional *Heli-Coil* Inserts insure threaded fastener security throughout the starter.

at 46,000 R.P.M.

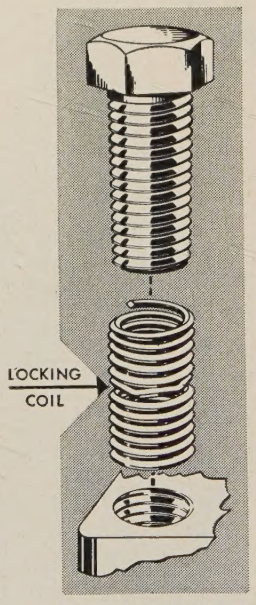
HELI-COIL®

SCREW-LOCK INSERT*

holds this vital bolt fast
...Without Lock Washers
or Lock Wiring!

Even when the turbine shaft of General Electric's new AS-18 turbostarter whirls at 46,000 rpm... the key bolt at the end of the shaft can't work or wear loose. General Electric puts a one-piece, *internal locking* **Heli-Coil** Screw-Lock Insert in this tapped hole, gets thread security in this important threaded assembly despite vibration met at high shaft speeds.

In addition to the critical shaft application, General Electric uses more than 40 of these ***Heli-Coil*** stainless steel wire inserts throughout this compact 165 hp starter for aircraft gas turbines. Production and performance benefits? Unshakeable fastener security *without* the use of clumsy, heavy lock nuts, lock washers and lock wiring... lighter weight... less installation cost... faster and easier assembly and disassembly of this tiny power pack that weighs only 46 pounds! *Patented



Principle of ***Heli-Coil*** Screw-Lock Insert. Locking center coil grips screw in tapped hole; holds screw firmly against vibration and impact.

***Heli-Coil* Screw-Lock Inserts**

- positively lock screws and bolts against loosening under impact and vibration
- prevent thread wear, stripping, corrosion, galling and seizing
- eliminate lock nuts, lock wiring, other supplementary locking devices
- can be used in standard proportion bosses without need for redesign
- are available in a complete range of U.N.C. and U.N.F. thread sizes
- save assembly time, space, weight and cost
- meet military specs for locking torque and vibration

HELI-COIL CORPORATION
DANBURY, CONNECTICUT

HELI-COIL CORPORATION, 107 Shelter Rock Lane, Danbury, Connecticut
Send complete design data on *Heli-Coil* Screw-Lock Inserts
NAME_____ TITLE_____
FIRM_____
ADDRESS_____
CITY_____ ZONE____ STATE_____ 1772

IN CANADA: W. R. WATKINS CO., Ltd., 41 Kipling Ave., S., Toronto 18, Ont.
Write in No. 4 on Reader Service Card at start of Product Preview Section

cover story

How the first American will go into orbit around the earth is shown symbolically on our cover—launch of the Mercury capsule by an Atlas ICBM booster, orbital flight of the separated capsule, and parachute recovery of the capsule. For a report on the kind of engineering that is going into this project, turn to the article on *page 42*, which gives the first detailed description of the air conditioning and pressurization system AiResearch has designed for the McDonnell capsule in an exclusive by associate editor Irwin Stambler.

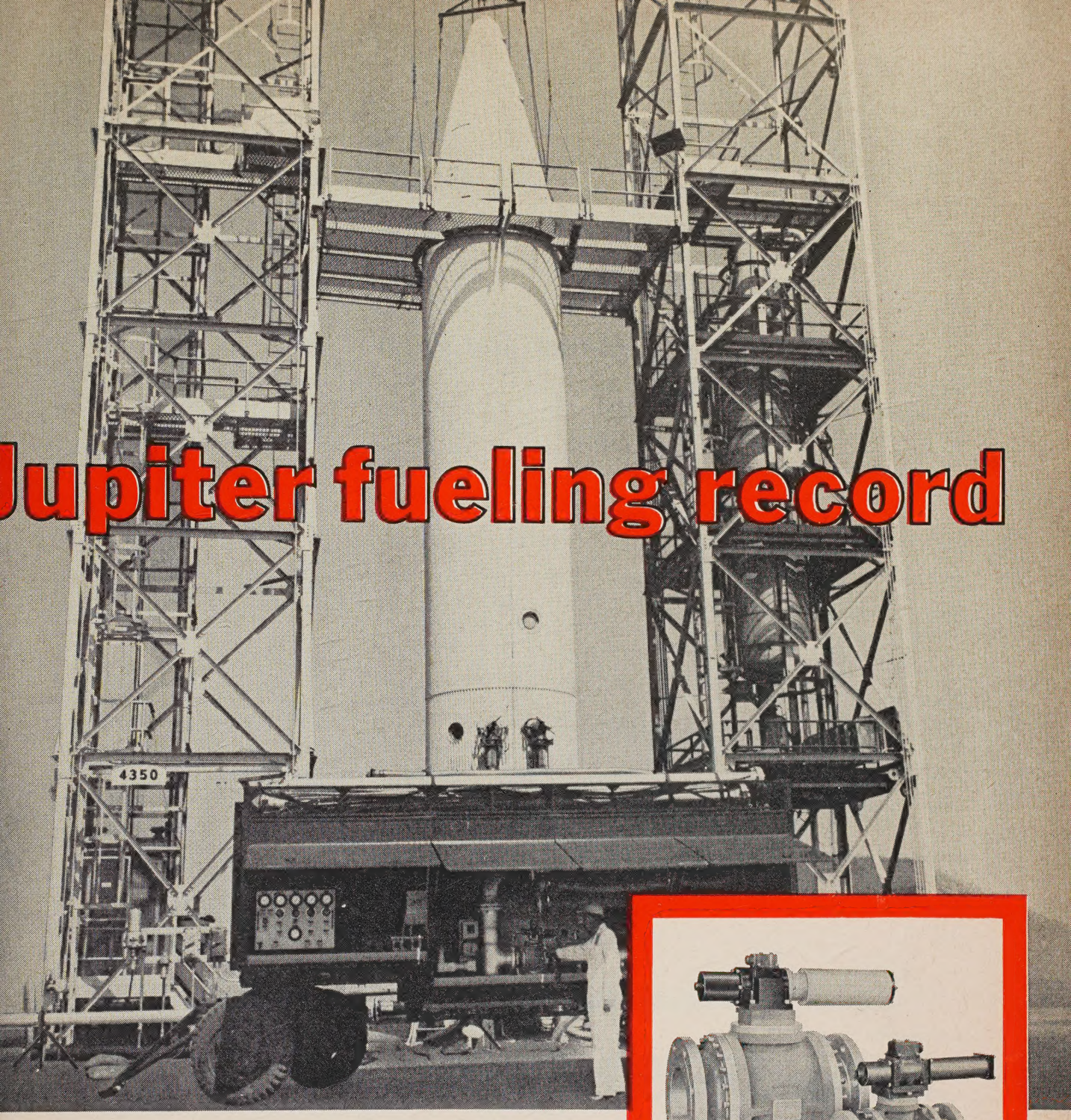
Published by Conover-Mast Publications, Inc.

B. P. Mast .... Chairman of the Board
B. P. Mast, Jr. ..... President
William G. Maass ..... Vice President
A. M. Morse, Jr. ..... Vice President
A. H. Dix .... V.P. & Dir. of Research
Harvey Conover, Jr. .. V.P. & Secretary
Leo Haggerty ..... Treasurer
John T. Dix .... Dir. of Midwest Oper.
E. H. Howard ..... Promotion Mgr.
L. E. McMahon ..... Production Mgr.
D. G. Smith ..... Circulation Mgr.

Other Publications

Business/Commercial Aviation
Boating Industry
Mill & Factory—Purchasing
Electrical Manufacturing
Construction Equipment
Volume Feeding Management
Conover-Mast Purchasing Directory

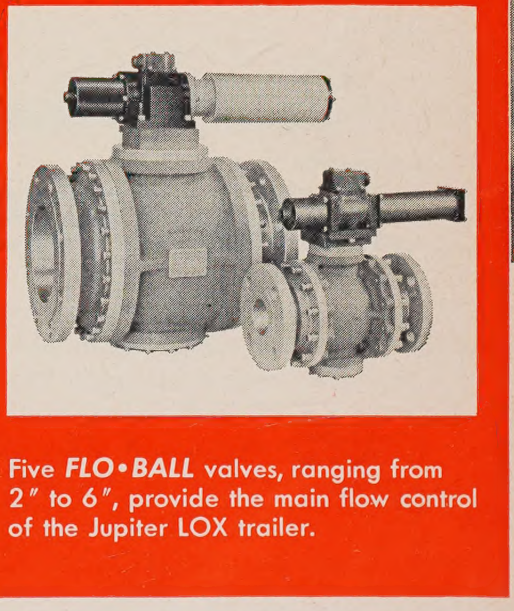
BPA *Associate Members* NBP



Jupiter fueling record

made possible with Hydromatics *FLO-BALL* valves!

100% flow efficiency, most compact size and lightest weight make these Hydromatics ***FLO•BALL*** valves excel in every major missile, aircraft and ground support system. ***Write for complete information.***



Five ***FLO•BALL*** valves, ranging from 2″ to 6″, provide the main flow control of the Jupiter LOX trailer.

Hydromatics, Inc.

LIVINGSTON, N. J. • WYMAN 2-4900 / LOS ANGELES, CAL. • DIAMOND 6-6900

FLO• BALL

Write in No. 5 on Reader Service Card at start of Product Preview Section

July 1959

volume 32, number 1

space/aeronautics

Technical Management

EDITORIAL: The President's Dander—and Leadership 17
WASHINGTON BRIEFING: How NASA Sees Its Job .. 19
INDUSTRY VIEWPOINT: Should You Diversify into Non-Defense? 21
MANAGEMENT INTELLIGENCE 23
SPACE/AERO ENGINEERING INTELLIGENCE 29
Rising Demand for Technical Managers 40
SPACE/AERO ELECTRONICS INTELLIGENCE 115

Space/Aero Engineering

INTELLIGENCE 29

Systems Engineering

Ten-Man Space Station for Assembly in Orbit .. 52
DESIGN PROGRESS: Simple Mechanical Linkage Controls X-15's Reaction Jets 57

Dynamics & Structures

DESIGN PROGRESS: Simple Mechanical Linkage Controls X-15's Reaction Jets 57

Propulsion

Combustion Instability: Causes and Cures 46
Storable Liquid Propellants Look Good for Drone Rockets 75

Accessory Systems & Components

Environmental System For Mercury Capsule Is Simple, Rugged 42
Combustion Instability: Causes and Cures 46
DESIGN PROGRESS: Simple Mechanical Linkage Controls X-15's Reaction Jets 57
Six Rules for Evaluating CFVS Generators 93

Materials

New Tungsten Know-How Widens Design Horizons 48
Microstructure Affects Steel Fatigue Strength .. 85
Plasma Arc Process Coats and Forms Refractory Materials 105

Production Engineering

New Tungsten Know-How Widens Design Horizons 48
Plasma Arc Process Coats and Forms Refractory Materials 105

Human Factors

Heat Protection for Space Crews 61

Space/Aero Electronics

INTELLIGENCE 115
The Payoff of Missile Design: Electronic Fuzing .. 120
Are We Ready for Space Probe Data Transmission? 124
DESIGN DIGEST: MIG Platform Extends Inertial System Use 128
Tests to Failure Boost Sparrow I Reliability 133
Video Converter Puts Electronic Maps on Radar Scope 143

Features

Cover Story 6
In This Issue (Abstracts) 10
Keeping in Touch 14
Calendar 36
Books 81
Scanner 152
Employment Inquiry Form 157
Product Index to Advertising 167
Advertisers' Index 170
Equipment Briefs 175
Product of the Month 179
Product Preview 180
Data Preview 248
Letters 263
Industry Briefs 265
Readers' Round Table 266

The editorial content of Space/Aeronautics is regularly examined for readability by Robert Gunning Assoc., counselors in clear writing. These consultants meet periodically with the editors and discuss comparative readability ratings.

FAST, SMOOTH, DEPENDABLE

Fast, smooth, dependable... that sums up Convair's new 880 and the B. F. Goodrich Cladheat De-Icers that protect the empennage of this near-sonic jetliner.

Fast-acting ribbon type electrical heating elements with built-in temperature sensors are sandwiched between layers of resin-impregnated glass fabric. Then they are molded into a single unit and capped with a stainless steel skin. Six-foot sections bonded to empennage leading edges of the Convair 880 form a smooth, integral airfoil.

B. F. Goodrich Cladheat units reduce the possibility of re-freezing runback—cut power consumption to 15-18 watts per square inch by cycling small sections one at a time. And lightweight B. F. Goodrich Cladheat De-Icers are designed to function dependably, despite external impact damage.

B. F. Goodrich Cladheat De-Icers are available in metals of various thicknesses with power densities to meet *your* specific needs. *B.F. Goodrich Aviation Products, a division of The B.F. Goodrich Company, Dept. SA-79, Akron, Ohio.*

B.F.Goodrich *aviation products*

Write in No. 6 on Reader Service Card at start of Product Preview Section

in this issue

Here's a quick rundown of the technical information offered in the articles in this issue. You can also use these article abstracts to build up your own permanent record for reference in the future—just clip them, paste them up on standard three-by-five cards, and file them.

Space/Aero Engineering
Accessory Systems & Components

Astia code: 1-2
Your code:

Environmental Control System for Mercury Capsule Is Simple, Rugged

Detailed description of air conditioning and pressurization system for first U. S. manned satellite. The designs of key components, including odor and CO_2 absorber, compressor unit, heat exchanger, and water separator, are discussed.

by Irwin Stambler, Associate Editor
space/aeronautics 32/1 (July '59) **p. 42**

Space/Aero Engineering
Systems Engineering, Structures, Accessory Systems

Astia code: 1-2, -3; 9-6; 27-3
Your code:

Simple mechanical linkage controls X-15's reaction jets (Design Progress)

Diagrams and description of dual reaction control jet system on North American X-15. Also gives details on principal structural subassemblies and reports on development status and expected performance.

by Irwin Stambler, Associate Editor
space/aeronautics 32/1 (July '59) **p. 57**

Space/Aero Engineering
Propulsion, Accessory Components

Astia code: 27-2, -3
Your code:

Combustion instability: causes and cures

Analysis of combustion instability problems and their remedies in rockets, turbojets, and ramjets. Effects of ignition lag, injector design, and plumbing configuration are explored in detail.

by Kurt R. Stehling, Contributing Technical Editor
space/aeronautics 32/1 (July '59) **p. 46**

Space/Aero Engineering
Human Factors

Astia code: 28-3
Your code:

Heat protection for space crews

Discussion of basic theory of human heat balance. Effects of blood circulation and evaporative, radiant, convective, and conductive cooling are discussed as they influence design problems of manned flight (especially in spacecraft). Performance limits are shown as set by hyperthermia and skin temperature limits.

by Earl T. Carter, Ohio State U.
space/aeronautics 32/1 (July '59) **p. 61**

Space/Aero Engineering
Materials, Production Engineering

Astia code: 17-2, -7; 26-1
Your code:

New tungsten know-how widens design horizons

Discussion of recent breakthroughs in methods of fabricating tungsten. Methods of forging, extruding, drawing and spinning are covered. Properties of tungsten are given as well as possible design applications of new types of tungsten parts.

by Irwin Stambler, Associate Editor
space/aeronautics 32/1 (July '59) **p. 48**

Space/Aero Engineering
Propulsion

Astia code: 27-3
Your code:

Storable liquid propellants look good for drone rockets

Basic design criteria for storable liquid propellant engine systems for supersonic target drones. Detailed discussion of thrust chambers, valves and regulators, and propellants for optimium system application. Tables list characteristics of satisfactory and unsatisfactory oxidizers and fuels for storable systems.

by R. P. Reul, Radioplane
space/aeronautics 32/1 (July '59) **p. 75**

Space/Aero Engineering
Systems Engineering

Astia code: 2-1
Your code:

Ten-man space station for assembly in orbit

Second article in three-part series. Preliminary design analysis of major structural elements of manned space station. Detailed section drawings of the space station assembly to scale. Gives design approach to stabilization in space, communications, and nuclear power supply.

by S. B. Kramer & R. A. Byers, Lockheed Aircraft
space/aeronautics 32/1 (July '59) **p. 52**

Space/Aero Engineering
Materials

Astia code: 17-2, -5
Your code:

Microstructure affects steel fatigue strength

Summary of Bureau of Standards study of the effect of metallurgical structure on the fatigue strength of high strength steels. Data obtained indicates fatigue strength decreases with increasing amounts of retained austenite.

by Irwin Stambler, Associate Editor
space/aeronautics 32/1 (July '59) **p. 85**

To make filing easier, each abstract is coded according to the Astia Distribution Guide. Copies of this guide are available from Armed Services Technical Information Agency, Arlington Hall Sta., Arlington 12, Va. There is also room on the abstracts for you to insert your own key if you use a special coding system.

Space/Aero Engineering
Accessory Systems & Components

Astia code: 7-5
Your code:

Six rules for evaluating CFVS generators

Review of four basic constant-frequency, varying-speed generation systems, based on analysis of over 30 different designs. Energy considerations of slip systems, size problems, mechanical contrarotation, electromagnetic field rotation, power flow concepts, and reactive current problems are discussed.

by F. T. DeWolf, E. A. Erdely, E. E. Kolatorowicz, & W. R. Miller, General Electric

space/aeronautics 32/1 (July '59) p. 93

Space/Aero Electronics

Astia code: 19-4
Your code:

MIG platform extends inertial system use (Design Digest)

Design analysis of lightweight, inertial-capability stable platform built around floated rate gyros and accelerometers weighing under eight ounces each. Three- and four-gimbal configurations are covered by detail photographs, overall functional diagram, and comprehensive data on dimensions and mechanical and electronic design.

by Bernard Kovit, Associate Electronics Editor

space/aeronautics 32/1 (July '59) p. 128

Space/Aero Engineering
Production Engineering,
Materials

Astia code: 26-1
Your code:

Plasma arc process coats and forms refractory materials

Discussion of Linde "plasma arc" process for applying coatings of such materials as tungsten, alumina, etc., and forming parts of these materials. The operation of the plasma torch is described, and some typical applications are given.

by Irwin Stambler, Associate Editor

space/aeronautics 32/1 (July '59) p. 105

Space/Aero Electronics

Astia code: 8-7; 19-3, -5
Your code:

Video converter puts electronic maps on radar scope

Design features of an electronic map projection system are described. System electronically superimposes map of terrain with prominent natural and man-made features on plan-position-type display. Optics and principal circuits are treated in some detail.

by Bruce I. McCaffrey, Raytheon Mfg.

space/aeronautics 32/1 (July '59) p. 143

Space/Aero Electronics

Astia code: 8-3; 12-5; 22-10
Your code:

The payoff of missile design: electronic fuzing

Explains basic principles of electronic fuzing and reviews state of the art and potential of capacitive, inductive, magnetic, visible-light, infrared, Doppler radio, pulse radio, and FM-CW radar fuze types.

by William H. Doty, Electronic Specialty Co.

space/aeronautics 32/1 (July '59) p. 120

Space/Aero Electronics

Astia code: 8-2; 30-5
Your code:

Tests to failure boost Sparrow I reliability

Details of environmental tests-to-failure program used to upgrade Sparrow I reliability. Testing procedures are explained, statistical equations are derived, and failure percentages are plotted for individual units under high temperature, shock, and vibration.

by E. H. Derr, Sperry Gyroscope

space/aeronautics 32/1 (July '59) p. 133

Space/Aero Electronics

Astia code: 5-2; 8-1, -6
Your code:

Are we ready for space probe data transmission?

Analysis of communication problems involved in effective recovery of data from space probes. Ground receiver requirements are discussed, and the phase-lock technique of correlation detection is detailed. Directional and nondirectional probe antennas are compared for effectiveness.

by W. F. Sampson, Hallamore Electronics

space/aeronautics 32/1 (July '59) p. 124

Change of Address: Notice of new address should be given one month in advance. Please send old address along with new address, title and company to Circulation Mgr., SPACE/AERONAUTICS, 205 E. 42nd St., New York 17, N.Y. Enclose a recent address label if possible.

VIBRATION RESISTANT
MOISTURE RESISTANT

Completely interchangeable

New miniature connectors for avionic equipment meet MIL-C-26482 (ASG)

Actual size photo shows three pin bayonet coupling type Double stub type available Both types completely interchangeable with other miniature connectors.

BANTAM

ENVIRONMENTALLY-SEALED ELECTRICAL CONNECTORS

Electrically, mechanically, BANTAM connectors are designed for dependable performance despite environmental extremes. Copper alloy closed entry contacts, heavily gold-plated... moisture-proof resilient inserts... cadmium-plated shells of high-tensile strength aluminum... heavy spring tension for perfect interface sealing. Also available are potting boot and cable clamp types.

H. H. Buggie
TOLEDO 1, OHIO

TOLEDO FACILITY **BURNDY** CORP.
OMATON DIVISION

59-11

Write in No. 7 on Reader Service Card at start of Product Preview Section

Use the "Time-Saver"...

. . . our Reader Service Card opposite page 167 to get more information on any product mentioned editorially or advertised in this issue. It takes just three easy steps:

1 Write the reader service numbers of the items of interest on the Card.

2 Fill in your name, title, company, and address and check the type of project your work applies to.

3 Tear out the Card and mail it (no postage necessary.) Space/Aeronautics' Reader Service Dept. will get in touch with the manufacturers for you.

coming next month

STAGES THAT WOULDN'T separate have caused a rather staggering number of missile aborts. SPACE/AERONAUTICS will analyze the design factors involved in this problem.

ACOUSTICALLY INDUCED fatigue is becoming quite a problem in modern high performance transport aircraft. How it affects supersonic structures will be explained in a design analysis of one of the recent jetliners.

A GOOD EXAMPLE of how novel accessory design can go a long way toward keeping an airplane simple and compact will be shown in the Design Progress, which will cover the transmission system of one of the most remarkable recent fighters.

coming soon

AN ENTIRELY NEW method of analyzing gust loads on high performance vehicles will be presented in a detailed design study.

Aviation Operations Magazine, Aviation Service Magazine and Aviation Age Magazine are combined with Space/Aeronautics Magazine. All rights to the names Aviation Operations Magazine, Aviation Service Magazine and Aviation Age Magazine are reserved by Conover-Mast Publications, Inc. Copyright 1959 by Conover-Mast Publications, Inc., in the U. S. A. All rights reserved. Entire contents fully restricted. Every effort is made to verify the information published in this magazine. However the opinions of the authors are not necessarily the opinions of the publishers and this periodical accepts no responsibility in connection with any liability which might develop as a result of articles published. Published monthly by Conover-Mast Publications, Inc. Editorial and Executive Offices: 205 E. 42nd Street, New York 17. Single copy $1.00 except special issues. Subscription U.S.A. $10.00 annually; Canada, $15.00 annually; Other foreign $20.00 annually. Printed by Periodical Press Corp., Phila. 40, Pa.

AIR COMPRESSOR and VACUUM PUMP

TO MEET EXTREME AMBIENT REQUIREMENTS

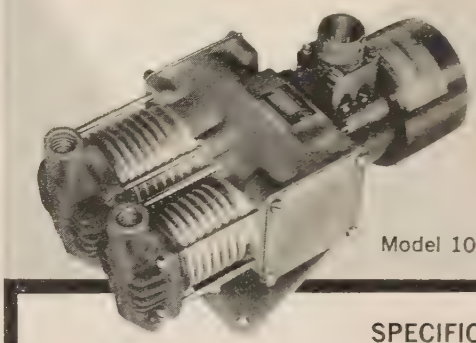
Oil-Free, Self Lubricated —
Qualified For 1,000 Hrs. Min. Life

Model 100-797-3 (shown below with specs.) operates efficiently within an ambient temperature range of minus 65°F to plus 200°F... meeting exacting customer and military specifications. This model is representative of a series of similar units designed and developed by Great Lakes to satisfy special requirements.

ATTENTION PROJECT GROUPS & SYSTEMS ENGINEERS!

Great Lakes can save you time and money by incorporating existing units in your design plans at an early stage. You will find that our Engineering, Designing, Testing, and Production Ability will augment your own facilities.

HIGH QUALITY MOTOR-DRIVEN AIR PUMP DESIGNED FOR USE IN AIRBORNE AND GROUND SUPPORT EQUIPMENT



Model 100-797-3

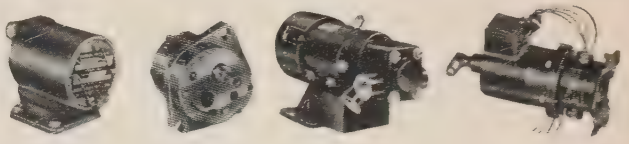
SPECIFICATIONS:

COMPRESSOR CAPACITY . . . .025 PPM at 30 PSI Absolute Outlet with 7 inches Hg. Absolute Inlet Pressure

VACUUM CAPACITY . . . Will reduce 800 Cubic Inch Volume from 29.92 Inches Hg. Absolute to 0.5 Inches Hg. Absolute in 2 minutes with Outlet Discharging to Sea Level.

DUTY CYCLE ..... Continuous

WEIGHT ..... 8.75 Pounds



Absolute Ref. PRESSURE SWITCHES | *4,000 PSI* HYDRAULIC PUMPS | *Motor-Driven* FUEL PUMPS | *Motor-Driven* COOLANT PUMPS

Some of the complete line of products designed and manufactured at Great Lakes.

Write today, for complete information on Great Lakes PNEUMATIC-FUEL-HYDRAULIC Components. An experienced Sales Engineer is available to discuss your requirements.

GREAT LAKES

MANUFACTURING CORPORATION

4223 Monticello Boulevard • Cleveland 21, Ohio

Write in No. 8 on Reader Service Card

Is the technical press useful?

RECENTLY one of our engineering editors came back from a field trip wearing a rueful look on his pan.

"What's the matter with you," asked Randy Hawthorne, SPACE/AERONAUTICS' Editor. "Someone run off with your slide rule?"

"Worse than that," moaned the e.e. "I've just had my ego busted. Didn't you tell me when I took this job that technical journals serve a useful purpose besides making money?"

"I may have given you that idea," the Editor cautiously admitted.

"Well," said the e.e, "you'd better explain how useful we are to this guy G, sales manager of X Company. He sat in on a round-table interview I was having with four department heads. Every time they opened their mouths to tell me what they were doing, he put the muzzle on them.

"Finally I asked what gives—wasn't there anything we could talk about? All I was getting was generalities.

"He gave us the back of his hand—very politely, however, I will say. Not only did he give us the back of his hand; he gave it to all trade books, news as well as technical. What really burned me, though, was that he had no use at all for editors.

" 'Anything you people publish,' G tells me, 'is more likely to hurt than help a company such as ours by giving away details to our competitors.'

"In short," finished the e.e., "he was treating *me* as a spy." Our engineering editor felt somewhat outraged as he thought that one over. "Funny thing was," he added, "it was *their* public relations who invited me out in the first place."

It isn't often we get such a brickbat bounced off our noggins—people usually are more polite. But every once in a while we run into a fellow whose soul needs saving.

"A useful working reference"

We certainly like to make money—we get as much kick out of that as the next one. And our editors don't have a noticeable aversion to the stuff. But not one would do the job he's doing for money alone. They all have to believe that what they're doing plays a vital part in the development of the aerospace industry and the country's defenses.

We get some evidence we are doing just that. The other day we ran across this in our mail:

"For our purposes, SPACE/AERONAUTICS is the ultimate in published periodicals—we consider SPACE/AERONAUTICS a 'must' in our operations." That was from the supervisor of special equipment design at Chrysler's Missile Division.

Another note, from the supervisor-measurements at General Electric, Lynn, Mass., said: "You have done a superb job in making this magazine a useful working reference."

A chemical engineer at Rome Air Development Center, wrote: "SPACE/AERONAUTICS . . . is rich in many phases of technical research and engineering. Of special mention is the selection of reports dealing in the space problems, research and development which are not removed from our everyday engineering work. I have found the reports extremely informative."

And from a NASA research engineer at Langley Field: "For the last year, SPACE/AERONAUTICS has been a valuable addition to the literature I find necessary to keep abreast of developments in the fast-moving field of aircraft, missiles, and spacecraft."

Technical journals fill the gap

We could go on citing the praise of the technical people who need the information supplied by technical trade magazines. These people are not only in companies competitive to that of sales manager G in X company. They also are the people who specify products for his customers. They are in military and government agencies and airline engineering departments. They need ideas from which to design the products G wants to sell.

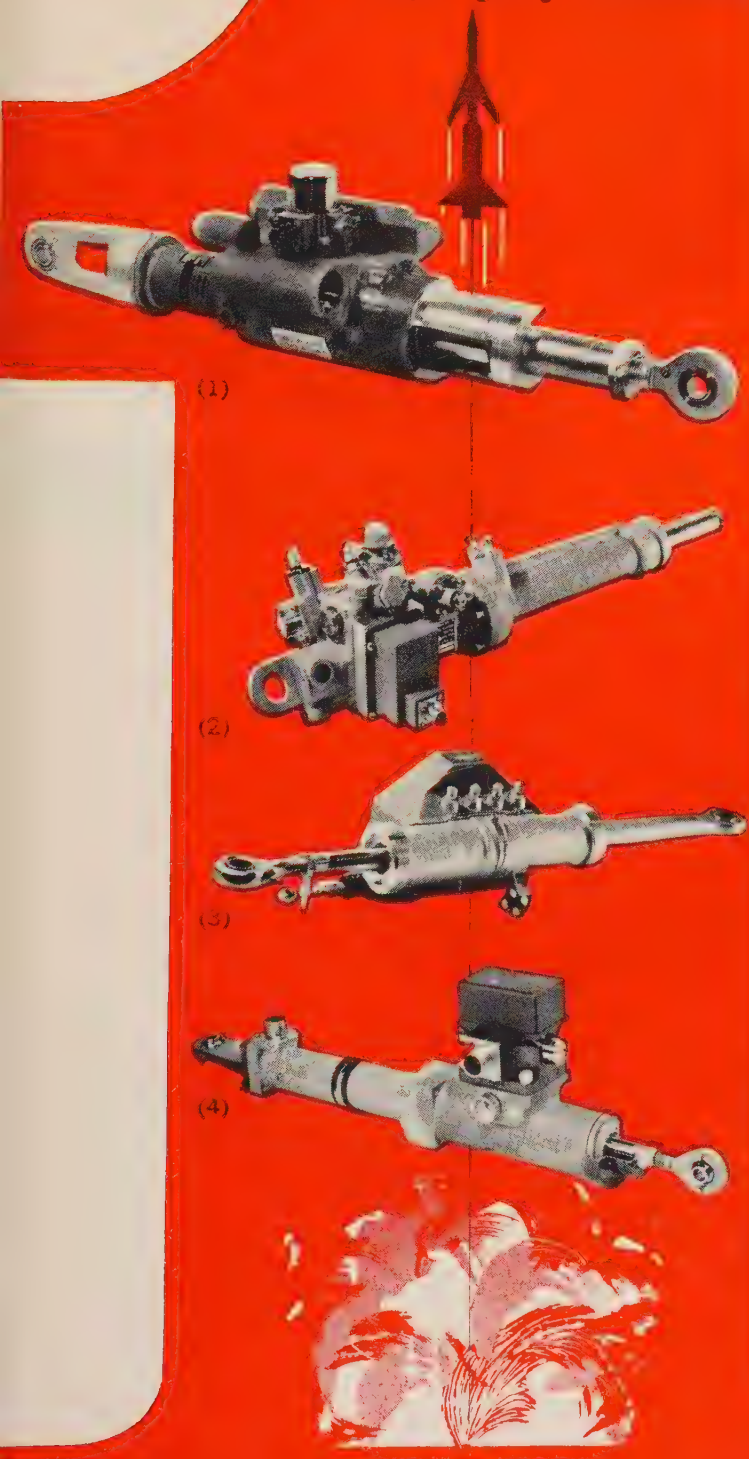
Every year we get requests by the thousand for specific information. These requests tell us that the information needs of aerospace technicians are not being filled by ordinary industry and government channels. Only trade journals can help fill the gap.

The communication of ideas is becoming an acute problem in the aerospace field. To choke off the flow more will in the end boomerang on the industry and the country.—End

William L. Mass

Publisher

high performance



CONTROL— IN ONE INTEGRATED PACKAGE

HYDRAULIC RESEARCH designs and builds complete packages for engine, flight and other precision control. Servo, actuator, filters, transducers, valves, potentiometers – all are integrated into one single unit that simplifies test and check. Hydraulic Research control packages are in use, now, on leading aircraft, missile and space craft.

Typical:

(1) **On ICBM.** Controls rocket engine position. **First fully qualified control actuator.** Features extreme environment servo valve.

(2) **On IRBM.** For engine positioning. Features mechanical position feedback.

(3) **On newest interceptor.** Actuates control surfaces. Features dual hydraulic systems. Responds to manual or electrical commands.

(4) **On satellite** (final stage). Engine position control. Features cylinder snubbers, and load limiters.

Hydraulic Research, **originator of the dry coil servo valve,** is thoroughly experienced in the servo and control field. Use this design background and proven production proficiency to your advantage. Write for further information.

HR

HYDRAULIC RESEARCH
AND MANUFACTURING COMPANY
Subsidiary of Bell Aircraft Corp.
2835 N. Naomi Street • Burbank, Calif. • Victoria 9-6111

Designers and Producers of

PRECISION ELECTRO-HYDRAULIC SERVO CONTROLS

HYDRAULIC & PNEUMATIC VALVES

PRESSURE SWITCHES

Write in No. 9 on Reader Service Card at start of Product Preview Section

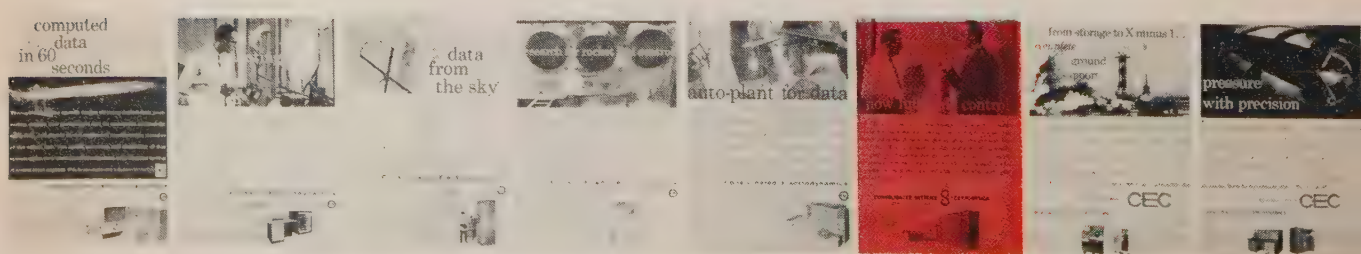
new symbol for systems

In five years of operation, Consolidated Systems has climbed from less than one-quarter million to over eight million dollars in custom-engineered systems for dynamic and static testing, chemical analysis, industrial control, and high-speed analog and digital data processing. This unprecedented growth in specialized systems (including missile ground support and cryogenics) is proof of quality – of performance – and of customer satisfaction. Over 500 systems have been designed, manufactured, and installed. These are *operating* systems producing data where time is critical and performance is paramount. Read about them in Bulletin CEC 1304-X53.

CONSOLIDATED SYSTEMS CORPORATION

1500 So. Shamrock Ave., Monrovia, California

A SUBSIDIARY OF CONSOLIDATED ELECTRODYNAMICS



Write in No. 10 on Reader Service Card at start of Product Preview Section

editorial

The President's dander–and leadership

PRESIDENT EISENHOWER is sore at the "munitions lobby". Not long ago he got his dander up over a question of who's the Pentagon expert. Every once in a while he gets a little hot under the collar over interservice squabbling. And Congress just upset him by making "decisions" affecting continental defense measures.

We like to see the President get his dander up on occasion. But we really wish he would keep it for Khrushchev's missile-rattling in Albania and threats to Berlin. We'd cheer if he blew his top over the Reds crushing the Tibetans, or killing 30 million Chinese peasants. We long to see him really upset over 17 Americans being shot down near the Turkish-Armenian border. And we very much would like to hear a large, sustained Presidential outburst over inflation.

A President speaking publicly his outrage on these points could have a profound effect. At least there would be more impact to it than telling a group of newsmen his feelings about the munitions lobby in a "voice edged with anger."

BUT ALL the things Mr. Eisenhower has bristled about before newsmen have been caused by something within his control. This is his lack of leadership.

Why is Congress making decisions about the Nike-Bomarc dispute? It is because no clear-cut decision has been made by the President, or Mr. McElroy, or the Joint Chiefs, or anyone else. The "decision" to go ahead with both is not a decision. It reflects merely the indecision to drop one or the other, or both.

Why do the services continue their running fight over weapon control? Because no decision has been made at the top that clearly defines service missions and responsibilities. Why, there are not even now standards to determine how much is enough. For instance, how much is enough for the atomic retaliatory force? For air defense? For limited warfare forces? For strategic airlift and sealift? For reserve-type forces? No one knows. There are only opinions.

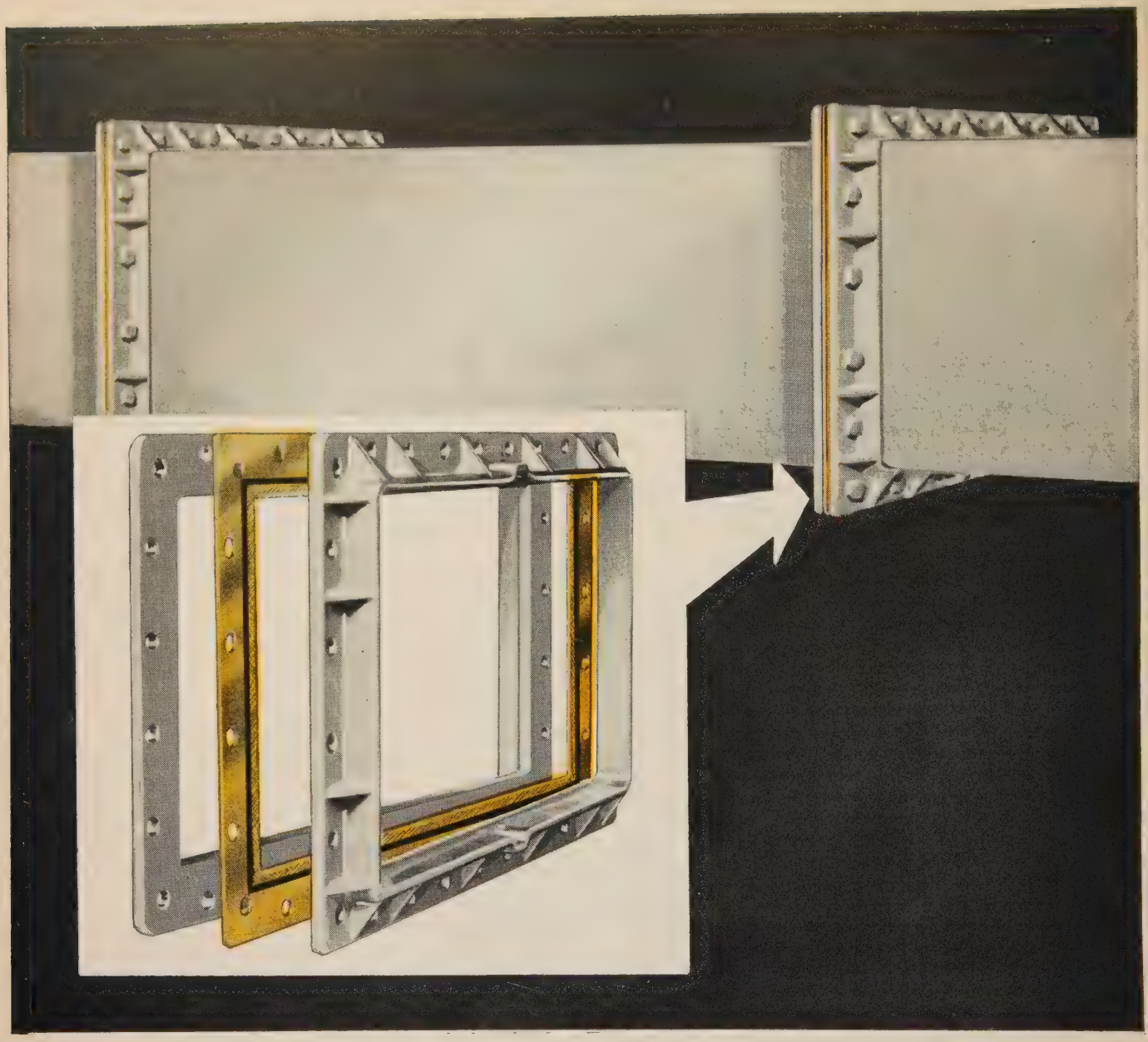
Because no standards exist, everybody is an expert on military requirements. If Mr. Eisenhower is the Pentagon expert he fancies himself, then maybe he will come up with a method by which the Joint Chiefs can do more than decide whether we should have one or two War Colleges.

WE NEED HIM to "sound off" on matters not entirely in his control. He should start a series of talks on the inflation problem, and what's causing it, if he believes that is a peril.

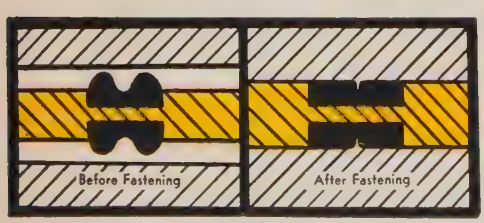
The world, sick to death of dictators' threats and brutality, would welcome a moral condemnation of Mao, Khrushchev, and their whole brutish crew. Why only cry or keep publicly silent over unjust accusations made by the Reds? Why don't we keep banging them about the ears with all the sickening crimes committted by these criminals? There is more than enough ammo to turn the tables on them.

Let's have both dander and leadership, Mr. President.

Randolph Hawthorne, Editor

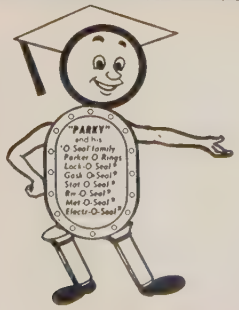


THESE WR WAVE GUIDE SEALS PROVIDE POSITIVE SEALING; PREVENT R/F LEAKAGE, ARCING & BURNING



Electr-O-Seals® are now available to fit all EIA (RETMA) standard WR series wave guide flanges, WR90 thru WR2300 as well as specials.

These seals not only provide near perfect sealing and complete electrical continuity, but offer many economical advantages — made by the makers of Parker O-rings, Stat-O-Seal®, and Gask-O-Seal®.

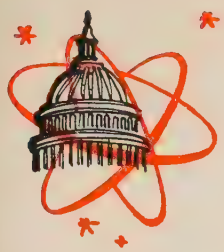


Parker SEAL COMPANY

CULVER CITY, CALIFORNIA and CLEVELAND, OHIO

A DIVISION OF PARKER-HANNIFIN CORPORATION

Write in No. 11 on Reader Service Card at start of Product Preview Section



washington briefing

by **A. N. Wecksler,** Washington Bureau Chief

How NASA sees its job

PRODDED into space as we were by Soviet successes, our research has gained momentum, and NASA has developed a concise outline of what we already know and what we want to know in the broad areas of space technology.

These areas are atmospheres, ionospheres, energetic particles, electric and magnetic fields, gravitational fields, astronomy and biomedical sciences.

Investigating these fields involves scopes that are far beyond many of the problems inherent in aircraft, but spacecraft, missiles, and aircraft all share common problems. An example of this similarity in problems is that vehicle such as the rocket-boosted Dyna-Soar glider, the nose cone of an ICBM, and the manned Mercury capsule all have the same fundamental problems of reentry.

Consequently, research that applies to spacecraft can have equal or even superior value for missiles and/or aircraft. There are many areas of aeronautics and astronautics where research benefits both.

NASA spokesmen shy away from any firm estimate of how much of their research effort is being directed toward aeronautics and how much toward space flight. In a rough measurement, however, it is estimated that just under half of the research in aerodynamics and flight mechanics is applicable to aircraft.

This does not argue the fact that as space has become more glamorous, there has been some research shift out of aircraft and into spacecraft and missiles.

When NACA became NASA, the organization was thrown fully into space research, with little time to achieve balance.

NASA had to get going, and had no time to build up its professional manpower by recruitment—which meant that experienced personnel working on aircraft research were pulled into research or development work on space problems. The total budget for research went up, but there was less for aircraft.

When experienced NACA personnel were shifted to space research, they were replaced by new hires. This tended to slacken off the pace of research in problems peculiar to aircraft.

At the same time, the demand for research on specific new aircraft has slackened off as there are fewer new aircraft. Currently, only the "chemical" B-70 bomber and the F-108 require a large amount of research. The Navy's problems with the A3J and the F4H have been pretty much solved. In the pre-missile period, the services had many more aircraft under development, and so there were many more research problems to work on.

NASA's role in researching the X-15 has been restricted to instrumentation and tracking. However, once the contractor has completed the demonstration flights, the plane will become a major test vehicle for NASA and the military services.

In broad areas of aircraft research, work on transonic aircraft is decreasing because most of the problems have been resolved. In supersonic aircraft, research is increasing, and in addition NASA is exploring the feasibility of hypersonic-cruise aircraft.

There is little NASA research interest in the helicopter, and (based on the thinking that there is little area for further research) little in sea-based aircraft. On the other hand, the attitude toward VTOL and STOL aircraft is that both types have useful military and commercial applications.

As a result, research in VTOL and STOL designs has been maintained, and even somewhat increased.

The present NASA conclusion is that a combination VTOL-STOL is preferable to two separate types—that for practical opperational use, both VTOL and STOL capability will be required.

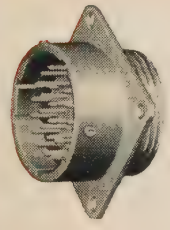
This roughly is NASA's position. In answer to public and Congressional clamor, the agency is pursuing a bold drive into space, on the general premise that its research in the space fields will benefit the high speed aircraft. In the other aircraft types, NASA is trying not to neglect any specific type of aircraft, but is slackening off where the gains appear minimal, and is concentrating where it appears that its research efforts can accomplish most.

BENDIX* PYGMY* MINIATURE ELECTRICAL CONNECTORS

Presenting our big and growing family

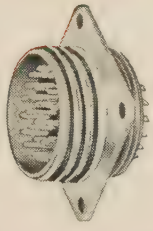
*TRADEMARK

TYPE PT



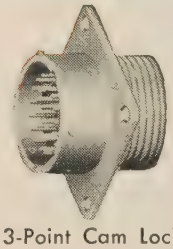
3-Point Cam Lock

TYPE PC



Double Stud Thread

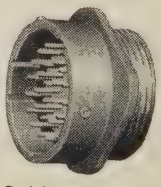
TYPE SP



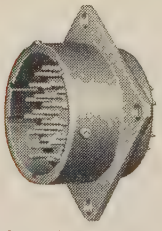
3-Point Cam Lock Back Panel Mounting

THE PT SERIES
(Typical of PC and SP)

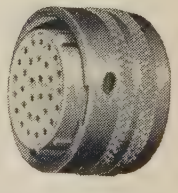
Wall Mounting Receptacle



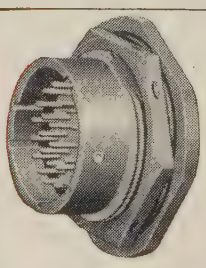
Cable Connecting Plug



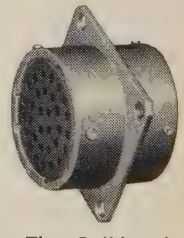
Box Mounting Receptacle



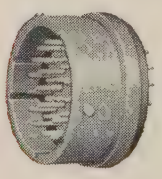
Straight Plug



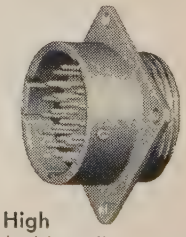
Jam Nut Receptacle



Thru-Bulkhead Receptacle



Solder Mount Receptacle

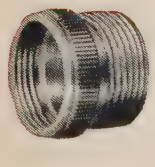


High Ambient (In Design)

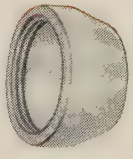
FAMILY FEATURES

- Lightweight, Compact
- Resilient Inserts
- Closed Entry Sockets
- MS Mtg. Dimensions on PC & PT Series
- 5 Key Polarization on PT & SP Series
- Heavily Gold Plated Contacts
- Moisture and Vibration Resistant
- Quick Disconnect—All Series

TERMINATIONS

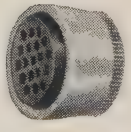


"A" General Duty



"P" Potting Boot

"A" (SR) Strain Relief



"E" Open Wire Seal

"W" Cable Seal

Specify Bendix Pygmy Miniature Electrical Connectors for the minimum space and weight required to serve the most critical circuitry.

Scintilla Division
SIDNEY, NEW YORK

Bendix AVIATION CORPORATION

Export Sales & Service: Bendix International Division, 205 E. 42nd Street, New York 17, N. Y. Canadian Affiliate: Aviation Electric Ltd., 200 Laurentien Blvd., Montreal 9, Quebec.

Write in No. 12 on Reader Service Card at start of Product Preview Section

industry viewpoint

by **Robert M. Loebelson,** Associate Editor

Should you diversify into non-defense?

ONE OF THE BIGGEST problems facing top management in the aerospace industry involves the decision whether to attempt diversification into non-defense activities. The answer is far from clear-cut, especially when industry executives know that they can continue to make a small profit for their stockholders without large financial risks by continuing to produce primarily for the services.

To William A. M. Krebs, vice president of Arthur D. Little, Inc., of Cambridge, Mass., the main reasons for attempting non-defense diversification are:

- A single product line of military hardware or business with a single military service provides a precarious perch for continued existence. "Even varied products marketed among a number of Government agencies," says Krebs, "leave the enterprise hostage to the fast unpredictable swings and surges of budgets and political expediency. A broadened product line, balanced with items for the civilian market, can impart increased stability both to production planning and income."
- Government contracts provide low margins of profit, especially when the actions of the Renegotiation Board are considered. Krebs believes these low profit margins are justified in most cases because of the relatively low risk and low capital investment of the companies involved. But he adds, "Such margins as a steady diet make for thin enterprises."
- The limitations imposed on proprietary rights under Government patent policies.

Krebs points out that defense producers who remain just that for a long time are looked at skeptically both by management leaders and by top technical talent. "Ultimately," he asserts, "even the financial market will share this skepticism." And this will cause both skill and capital to be withdrawn or withheld.

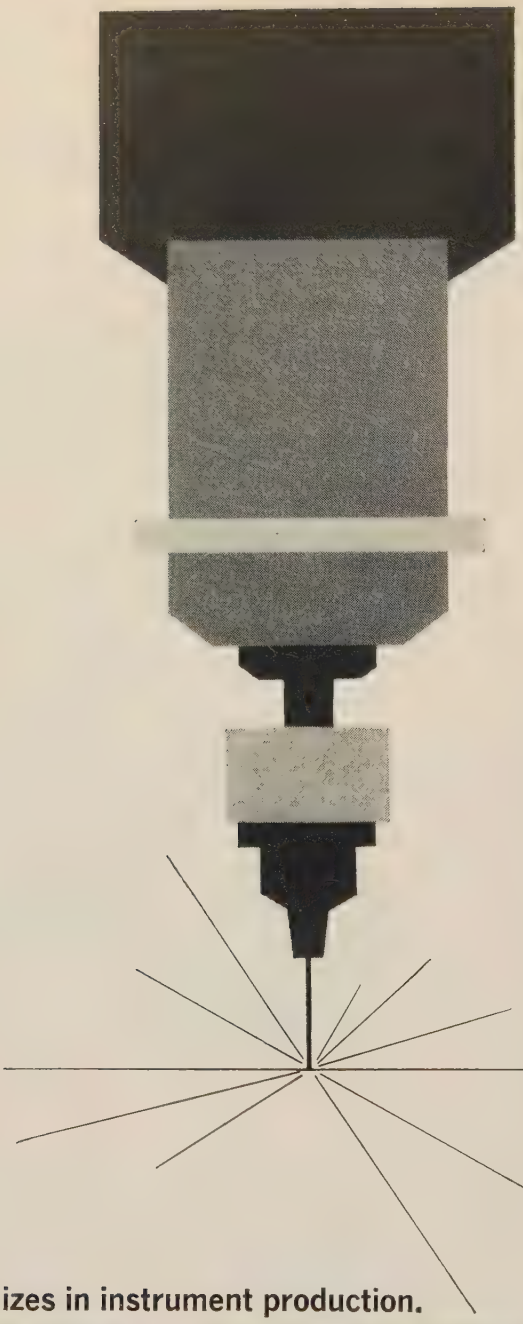
WILLIAM A. M. KREBS, vice president, Arthur D. Little, Inc.

- By contrast, the ADL executive declares, any firm with a reputation for successfully converting military know-how into production for the more stable (and profitable) civilian market can use that reputation to recruit top talent and attract new investors.

The ADL vice president maintains that the differences between producing for the military and for the civil market show up in every area—from research and finance through production. But the major difference is in marketing.

A defense producer, Krebs says, must first identify the civilian product to which defense skills can be applied. "The need which such a product will satisfy must then be established, the size of the market evaluated and competition identified. Price policy must be set with a sharp eye on both cost and competition.

The hazards in trying diversification are great, Krebs concedes, but "the rewards of success are worth the effort." Some companies in the industry have already made the effort, others are still studying the pros and cons.



Instrument parts and packages... by Bulova

Bulova group specializes in instrument production.

Men, machines and know-how—this is the make-up of Bulova's instrument manufacturing group. A completely separate facility employing manufacturing engineers, quality control teams, production, assembly and test personnel, standard machine tools, custom and Bulova-built equipment.

These special skills and facilities, working in close-knit unison, promise delivery of reliable products crafted to customer specifications and budgets . . . whether individual parts or complete packages.

Experience in precision design and precision manufacture is the Bulova tradition, the Bulova capability. It has been for over 80 years. For more information write—

Industrial & Defense Sales, Bulova, 62-10 Woodside Ave., Woodside 77, N. Y.

BULOVA

Write in No. 13 on Reader Service Card at start of Product Preview Section

AMID ATTACKS by President Eisenhower and others on the "munitions lobby," indications are that both the Nike-Hercules and Bomarc surface-to-air missiles will continue in production.

Castigation of the "munitions lobby" resulted from advertisements stressing the advantages of the Bomarc while House and Senate members were debating the merits of the two missiles. Hercules has a range of 75-100 miles; Bomarc will reach out to 400 miles in the B version.

ACTUALLY, much of the debate over the two missiles is wasted. While the present threat to the U.S. is from manned Russian bombers, the bigger, future danger comes from Red ICBMs and IRBMs fired from subs.

In this area, Nike-Zeus partisans appear to have won their fight for acceleration. DOD officials, including the late Donald A. Quarles and Defense Director for Research & Engineering Herbert York, reduced Army requests for funds to order long-lead-time components and tooling for Nike-Zeus, while providing all the money the Army wanted for Zeus R&D work. House version of the Defense money bill for 1960 provides $200 million for these long-lead-time items. Senate will probably go along with House Appropriations Committee recommendations in the Zeus program.

Capitol Hill O.K.'s increase in Atlas squadrons from nine to 17

USAF WON ITS FIGHT—on Capitol Hill at least—to increase the number of Atlas ICBM squadrons from nine to 17. Originally, AF had programed nine Atlas and 11 Titan squadrons, each containing about 10 missiles. DOD may choose to withhold the added cash, as it has done on other programs in the past.

Reporting out the '60 defense money bill, House Appropriations Committee recommended a $172 million down payment for '60 to provide the eight additional Atlas squadrons. The cash will also cover a speed-up on the Boeing Minuteman solid ICBM program and on anti-sub weapons.

CONGRESSIONAL approval of the additional Atlas squadrons does not change plans for the Titan. USAF still intends to procure this more advanced ICBM.

Titan, incidentally, is now nearly two years behind the Atlas as far as operational use is concerned. First operational Atlases are in the hands of USAF troops at Vandenberg, AFB, Calif.

40 B-58s, 70 B-72s, 96 KC-135s voted by House

HOUSE VOTE of $17,767,200,000 in new money for USAF for '60 includes $4.2 billion for aircraft procurement, $2.5 billion for missile purchases, and $1.6 billion for research, development, test and evaluation (RDT&E).

Among the 654 planes are 40 B-58s, 70 B-72s, and 96 KC-135 tankers. Other planes in the procurement program are the Republic F-105, North American B-70 and F-108 (development work), troop carrier aircraft, jet trainers, helicopters, and aircraft used for airborne early warning and control.

MISSILE CASH covers Atlas, Titan, Mace, Minuteman, "minor procurement" of the Thor IRBM, Hound Dog, Quail, Bomarc, and target drones.

RDT&E money includes $75 million to cover development work on the direct-cycle GE X-211 nuclear engine, $10 million for Dyna-Soar, as well as funds to improve projected USAF aircraft and missiles. About 10 per cent of AF's RDT&E funds, or $116.9 million, is allocated for "support systems."

Eliminated were 10 jet cargo planes, 15 jet utility trainers, and 14 jet navigation trainers.

House appropriates over $1 billion for Navy research

NAVY ALLOCATION of $11,025,103,000 by the House for '60 includes $1.97 billion for aircraft procurement, $627 million to buy ordnance and ammunition, and just over $1 billion for RDT&E.

Airplanes to be purchased number about 700 and include the F4H, A3J, S2F-3, T2J, P3V, transports, search and warning planes, and helicopters for the Marines.

MISSILE MONEY covers Polaris, Sparrow III, Bullpup, Sidewinder, Talos, Terrier, Tartar, Asroc, Subroc, and target drones.

Among the projects on which the Navy will

more on next page

use its $1 billion in RDT&E money are $220 million for Polaris, $25.4 million for Tartar, and $100 million for "other Navy research."

ARMY WAS VOTED a total of $9.2 billion for '60 by the House, including $1.232 billion for procurement of equipment and missiles.

The procurement cash includes $200 million to acquire advance components for the Zeus anti-ICBM, funds for seven Grumman AO-1 turboprop Mohawks for observation missions and 42 de Havilland Caribous for cargo airlift, 100 H-13s and H-23s, 90 HU-1s, the Vertol HC-1B, and various missiles, including Pershing, Hercules Sergeant, Hawk, Shillelagh, Little John, Lacrosse, and Davy Crockett.

OCTOBER was set as the target date for the first firing of the cluster of eight Rocketdyne engines which will provide 1,300,000 lb thrust for the Army-ARPA Saturn. First flight test of Saturn is programed for the middle of 60.

Saturn will operate even if only seven of its eight engines ignite.

Electronics spending by NASA expected to rise to $2 billion a year by '70

ELECTRONIC Industries Association expects total appropriations for space projects to reach about $14 billion by fiscal '70. Electronics will account for about $4.8 billion of the total.

One major area of spending on electronics will come from NASA, the association believes. NASA funding is expected to rise from the current half-billion-a-year level to nearly $2 billion by 1970. EIA says NASA's expenditures on electronics for space will climb from the present 20 per cent to almost 45 per cent by the 1960's.

•

WITH THE FIRST N-156F ground support fighter scheduled to fly in July, Northrop's Norair Division is readying an intensive sales effort directed toward NATO and SEATO nations.

Low price tag may appeal to several countries seeking a lightweight supersonic fighter. Norair estimates the plane, produced in the U.S., would cost only $500,000 (including a fire control system) if the production run was as high as 1000.

Comparable price in Japan (based on a 1000 production run) would be $273,000, including airframe, engines, communication, navigation, and identification equipment. A fire control system like the ASG-20 would add $32,000 to the unit price.

Other possible production sources for SEATO countries are in Australia, where either Commonwealth Aircraft or the government-owned facility could turn out the N-156F.

Joint N-156F production discussed with Fokker, Sabca and Fiat in Europe

NORAIR has also been discussing production of the ground support fighter with Fokker in Holland, Sabca in Belgium, and Fiat in Italy. If the deal works out, each of the European firms would build part of the aircraft and its country's air force would get completed N-156's in return.

Eventual powerplants for the N-156F, which is based on the USAF T-38 supersonic trainer, are a pair of GE J85's, fitted with afterburner.

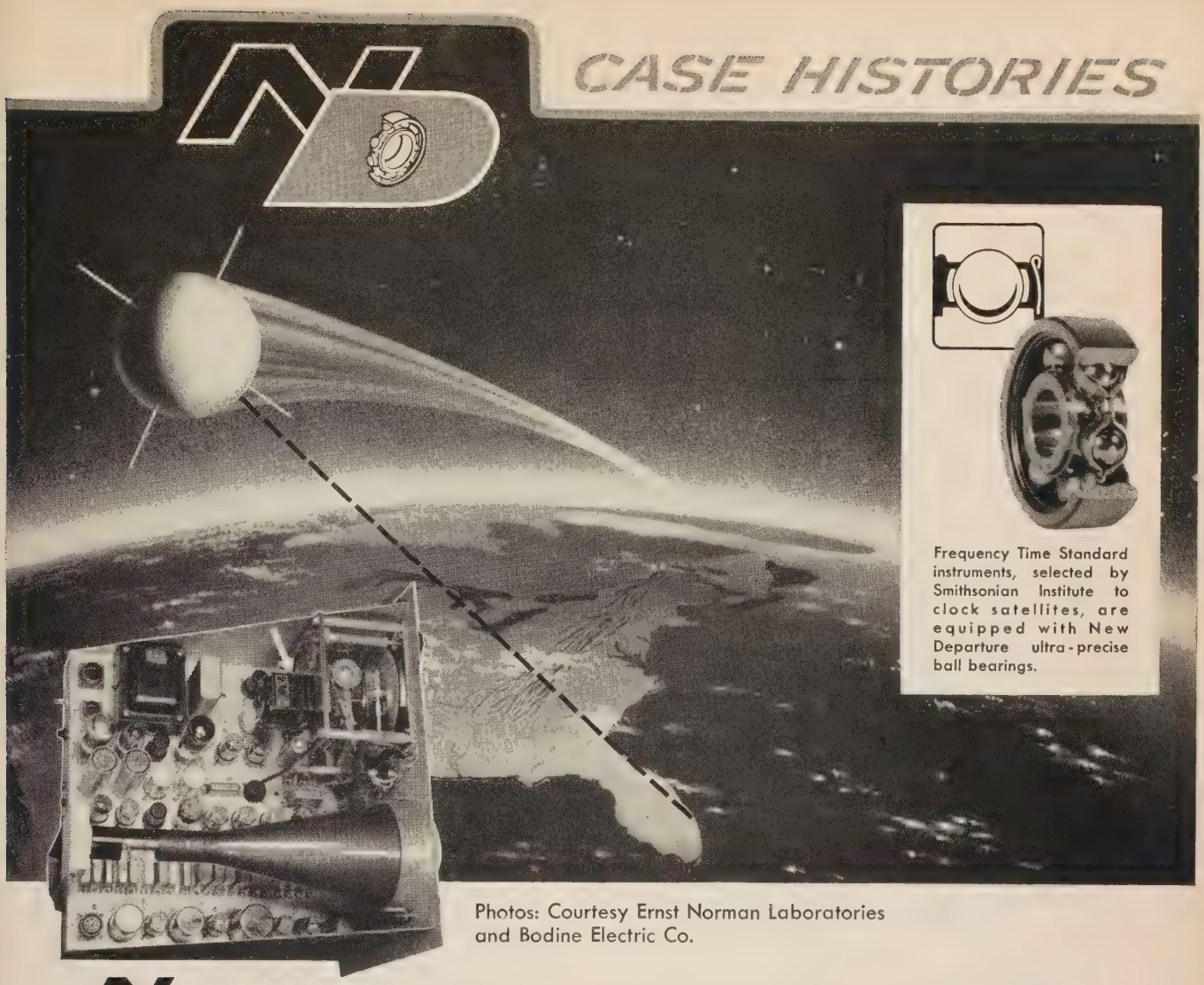
•

GENERAL ELECTRIC's engine production facilities at Evendale, Ohio, and Lynn, Mass., are making substantial progress in developing and delivering new powerplants:

- J93 "chemical" engine for the B-70 and F-108 is progressing satisfactorily in tests to date.
- J79 will appear in a new version, the J-79-9, for the Convair B-58B.
- Aft-fan version of the J79, the CJ-805-21, has been sold for use in the Convair 600 by American Airlines. Deliveries have not yet begun.
- Standard CJ-805-3, used in the Convair 880, is already being delivered to San Diego.
- Small turbofan in the 7000-9000-lb thrust class is under development for service in '62. Engine would be used on short-to-medium range jet airliners. Military services seem uninterested in turbofans of this size, but airlines may buy between 800 and 1200 of them in the '60's.
- X-211 nuclear engine is still undergoing tests at both Evendale and Idaho Falls, Idaho.
- J85-5 (with afterburner) for the T38 and the N-156F is scheduled to complete 500-hour tests this summer. Deliveries have already started and are increasing.
- J85-7 (without afterburner) for the McDonnell Quail decoy missile is also being delivered.
- T58 shaft turbine, used on various helicopters, is being delivered in quantity from Lynn.
- T64, Navy-sponsored convertible turboprop-turboshaft engine, is under tests, will be

more on page 26

CASE HISTORIES



Frequency Time Standard instruments, selected by Smithsonian Institute to clock satellites, are equipped with New Departure ultra-precise ball bearings.

Photos: Courtesy Ernst Norman Laboratories and Bodine Electric Co.

Ultra Precise Ball Bearings Help "Clock" A Satellite!

CUSTOMER PROBLEM:

Require ultra-precise bearing design for Bodine electric motor used in satellite-tracking micro-clock. Bearings must provide uniformly low starting torque, precise location of rotor shaft and minimum maintenance, to help mechanism achieve time determinations to 0.001 second.

SOLUTION:

N/D Sales Engineers studied special bearing requirements, and recommended New Departure ultra-precise ball bearings. These ball bearings measured up to every requirement for micro-clock motors . . . thanks to New Departure's advanced equipment for research, development and production. N/D equipped micro-clocks, selected by the Smithsonian Institute, are operating in a dozen locations around the world right now, keeping track of vital satellite movements . . . to accuracies of one millisecond and better!

If you're manufacturing or designing electric motors for any high precision applications, including instruments, why not call on New Departure? N/D engineering and research facilities are turning out the latest in high precision instrument ball bearings and advanced ball bearing designs. For more information write Department H-7.

NEW DEPARTURE

DIVISION OF GENERAL MOTORS, BRISTOL, CONN.

NOTHING ROLLS LIKE A BALL

Write in No. 14 on Reader Service Card at start of Product Preview Section

ready for service in 2-3 years. A straight jet version of the T64 (about 1700 lb thrust) is also a possibility.

• Second-stage engine for NASA's Vega space vehicle, based on the first-stage rocket developed for Vanguard, is under development and on schedule.

Wider use of liquid hydrogen foreseen by Air Force

USE OF liquid hydrogen as a storable liquid rocket fuel, considered "extremely difficult and problematical" until now because of handling and storage problems, is becoming a reality. USAF and the other services are certain that liquid hydrogen rockets will permit bigger payloads in the upper stages of missiles and space vehicles.

Biggest problem to date has been storage—liquid hydrogen must be kept at —420 deg F. USAF work on special refrigeration units and tank trailers has overcome this limitation.

Among the firms experimenting with liquid oxygen is Rocketdyne (at Santa Susanna, Calif.). Facilities producing the rocket fuel are located at Plainesville, Ohio, Palm Beach County, Fla., and Bakersfield, Calif. Other plants, located closer to rocket manufacturers, are being built in California.

CALLERY CHEMICAL next spring will report to NASA its findings on a new rocket propellant that will also provide substantial increases in payload weights. Callery, which will do the work for NASA at its Callery, Pa., lab near Pittsburgh, says the classified fuel is non-cryogenic and can have both liquid or solid applications. Working with Callery as a major subcontractor is Thiokol's Reaction Motors Division at Denville, N. J.

Decision on nuclear aircraft up to Dr. York now

DEFENSE SECRETARY Neil McElroy will base his decision as to whether to let USAF go ahead with a Phase I contract for a nuclear jet plane on the recommendation of Dr. Herbert F. York. York, DOD Director of R&E, inherited this job after the death of Deputy Defense Secretary Donald A. Quarles.

USAF has been straining for DOD approval for its Camal (*C*ontinuous *a*ir alert *m*issile launch *a*nd *l*ow level penetration bomber) project after concluding that experience with GE's X-211 reactor and split shielding warrant the green light. Convair and GE would get the Phase I award.

AF's Camal bomber will carry a four- or five-man crew, fly subsonically for as long as a week, and be able to operate from B-52 runways. It will carry air-launched ballistic missiles.

ONE POINT holding up the DOD decision—even if York and McElroy feel USAF progress with the direct-cycle engine and split shielding warrant a go-ahead—is the Navy's contention that a water-based recon plane for early warning and anti-sub warfare is vital. Navy feels an A-powered seaplane is the ideal answer. And the Navy also is pushing for an atomic turboprop rather than turbojet.

In related fields, Goodyear Aircraft is proposing a nuclear-powered airship, and Marquardt has received USAF and AEC contracts to expand its Project Pluto efforts to develop a nuclear ramjet.

3000 letters delivered by missile (but slower than by 707 jet)

FIRST USE of guided missiles for civilian purposes involved delivery of about 3000 letters by a Chance Vought Regulus 1 fired from the USS Barbero submarine to Mayport, Fla., near Jacksonville.

Although the Regulus firing was basically a stunt, it did prove missiles can be used for high speed mail deliveries. (Air mail carried by a Boeing 707 flies faster than did the letters in the Regulus.)

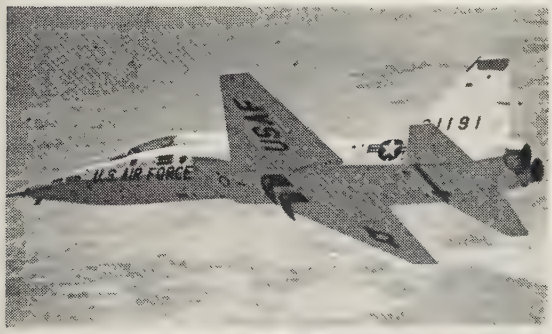
•

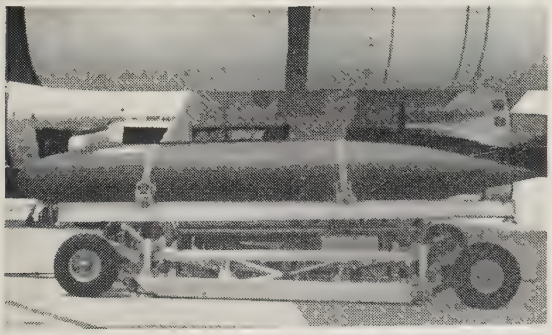
FIFTY-NINE Electras will get nacelle retrofits to lessen propeller vibration. Costs will be borne by Lockheed. Nacelles will be tilted upward three degrees.

NAVY NAMED Sperry's Marine Div., as the navigation systems manager for the new, second-generation Polaris submarines. This is the first nav system managerial award made by Navy.

Blind underwater navigation depends on inertial guidance, backed up by a series of devices that measure ocean currents and allow underwater star fixes through the periscope. A Navdac (*N*avigation *d*ata *a*ssimilation *c*enter) computer accepts information from 12 such sensors and figures bearing and position.

...NEWS IS HAPPENING AT NORTHROP





Shown above: Northrop's T-38 Talon, F-89 Scorpion and SM-62 Snark – all served by Nortronics' mechanical, electronic and servo-hydraulic GSE applications.

For the Hawk missile, Nortronics supplies Raytheon Manufacturing Co. with the loaders, launchers, and auxiliary handling equipment. Throughout concept, design and production, Nortronics has kept this program on – or ahead of schedule.

NORTRONICS TOTAL GROUND SUPPORT – KEY TO DEFENSE READINESS!

By integrating mechanical, electronic and servo-hydraulic skills into a wide variety of ground support equipment applications, Nortronics demonstrates an understanding of the total weapon system.

Nortronics conceives, designs and manufactures GSE around a knowledge of the weapon's mission, its operational and maintenance concepts, and the facilities and skills of its field operators.

Twenty years of specialized experience gives Nortronics the ability to get the job done – to translate your most complex GSE requirements into reliable hardware – on time – and at minimum cost.

For immediate help with your GSE requirements, call Nortronics today. Or write: Chief Applications Engineer, Dept. 2003-F3, Nortronics, 500 E. Orangethorpe Ave., Anaheim, California.

NORTRONICS
A Division of
NORTHROP CORPORATION

NEW DIMENSIONS IN

reliability

"to strive, to seek,
to find, and not to yield"
LORD TENNYSON

CADEL PRECISION PRODUCTS

reliability

A DIVISION OF GENERAL METALS CORPORATION
10777 VANOWEN ST., BURBANK, CALIFORNIA

DISTRICT OFFICES:
MINEOLA, L.I. NEW YORK • DAYTON, OHIO • WICHITA, KANSAS

GRAVITY DIFFERENCE detection instrumentation can provide major advantages for space navigation, J. J. Carroll and P. H. Savet, of Arma, told last month's IAS summer meeting in Los Angeles. Gravity gradient forces are small—about $10^{-7}G_s$/ft on the earth's surface and $10^{-10}{}_s$/ft at 36,000 ft—but suitable accelerometers can be designed. Gravity difference provides means of continuously or intermittently slaving a platform to stay tangent to the equipotential forces and for aligning the platform with respect to a satellite's orbital plane.

With gravity difference sensing, it will also be possible to shut down the guidance system for any length of time without impairing its future operation, Carroll and Savet stated.

FOR TEMPERATURES from 2600 to 3100 deg F, coated molybdenum alloy, dense silicon carbide, and coated graphite appear best for leading edges of hypersonic boost-glide craft of global range, F. M. Anthony and H. A. Pearl, of Bell Aircraft, told the meeting.

FOR MAXIMUM temperatures up to 2400 deg F, they report, niobium alloy, chromium-molybdenum-aluminum oxide cermet, chromium-tungsten-aluminum oxide cermet, and molybdenum disilicide looked best. Above 3100 deg F, tungsten and coated graphite are the two prime candidates.

Electric control foreseen for flight surfaces

CONTROL of primary flight surfaces solely by electric means may be needed for future supersonic aircraft, F. G. Keyt, of Minneapolis-Honeywell, told the meeting. It may provide a simple, lightweight, flexible system in place of today's increasingly complex designs, he stated.

Electric flight controls might be used only on aircraft that are sufficiently dependent on electronic damping to make such control attractive, or we might improve the reliability of an electric system to reach the level of a mechanical system, according to Keyt. In either case, he believes, the time to start designing an electric flight control system is now!

COMPARATIVELY SIMPLE equations representing ballistic re-entry vehicles with ablative nose cones can be used for configuration selection on computers, Quillinan, London, and Aston of GE, told the meeting. Optimum configurations have been selected in a matter of hours on an IBM 704, they stated. The prediction for the election program on weight and CG of production re-entry vehicles is within five per cent. In addition, a simplified method has been devised for the prediction of the minimum weight of re-entry vehicles, the GE engineers reported.

SOLAR or reaction-powered thermionic plasma diode may well be the space probe APU of the future, R. C. Hamilton, of Jet Propulsion Lab, told the American Rocket Society's recent semi-annual meeting in San Diego, Calif. A solar collector oriented to ±1 deg would concentrate the sun's rays at the focal point of a light-weight parabolic mirror to heat the cathode of a thermionic converter. Electrons in the hot (1000-2000-deg C) cathode would escape to the cold anode by virtue of their kinetic and potential energy and flow back from the anode to the cathode through an external load, doing useful work. A cesium vapor would be used to create positive ions, neutralizing the space charge and adjusting the work function.

POWER DENSITIES of around ¼ W/cm² are being obtained at a potential of 1000-1200 deg K for vacuum diodes, Hamilton noted. Substantial increases in power density, operating temperature, and life are expected in the next few years, he added.

Good handling characteristics reported for X-15

FIRST POWER-OFF X-15 flight at Edwards AFB, Calif., proved complete success, pilot Scott Crossfield of North American Aviation reported. Craft was launched from B-52 at 36,000 ft altitude; flight lasted about four minutes. A thrust-off descent, it was made with APU power for electric and hydraulic systems on.

Crossfield tested pitch, yaw, and roll controls and longitudinal stability. He reported handling characteristics were good, with complete control all the way down. "It was less difficult than expected," he stated, "and less difficult than test deadstick landings we ran with conventional jet aircraft." Landing roll at Edwards took about 5000 ft.

more on next page

STRIP-WOUND high strength steel rocket cylinders have been made by Ryan Aeronautical, of San Diego, Calif., R. J. Voth reported at a meeting of the Society for Experimental Stress Analysis in Washington, D.C. Test parts were made by wrapping 0.008-in.-thick steel strips on mandrels and tack-welding and then resistance-welding through all layers. Static-tension ultimate stresses of 305,000 psi have been obtained, Voth states.

YTTRIUM has received attention as an alloying element in Russia, recent translations reveal. Researchers at Institute of Metallurgy in USSR found that 0.1-0.2 per cent yttrium reduces grain size of many cast metals and improves their strength.

Studies also showed yttrium dissolves completely in cerium; interacts with aluminum, iron, and copper to form eutectic mixtures; dissolves very little in alloying with chromium, titanium, and zirconium.

Insulation breakthrough for long duration solid propellant rockets

RUBBER-ASBESTOS insulation devised at Astrodyne is reported by Navy to be major technological breakthrough in development of high performance, long duration solid propellant rocket motors. New insulation has resulted in test firings of solid propellant motors with significant thrust levels for durations of over 3½ minutes—an increase of 300-400 per cent over presently used solid motors, Navy states.

During runs, propellant with flame temperature of over 5500 deg F was used. Insulation kept the rocket case's exterior temperature to about 200 deg F after 3½ minutes.

ROLLOUT OF NORTHROP N-156F took place May 30 (see *S/A, "Overall Capability Is Key to N-156F Design," May 59, p. 52.*) "For the first time," T. V. Jones, president of Northrop, stated, "our own Department of Defense has applied advanced U.S. technology in a directed way to the military problems which exist abroad. From the outset, it has been planned that this airplane will be built in the countries which will use it and thus contribute to the economies of friendly nations outside the U.S. It is now clear that this plan will reduce the drain on the national resources of both the U.S. and its allies."

ASTRONAUTS can withstand forward accelerations of simulated three-stage rocket flights of 8, 10, and 12 G, tests at WADC's human centrifuge indicate. Rates of onset acceleration were calculated to give orbital velocity of 18,000 mph at third-stage burnout. Centrifuge was set to speed up at 0.5 G/sec to constant accelerations between two and 12 G, with acceleration maintained until subject suffered loss of critical faculty, pain or impairment of judgment.

Best body position for forward acceleration, states WADC, appeared to be with head and trunk tilted 25 deg forward and legs sharply bent. In this position, no blackout was observed, subjects endured 12 G for five seconds, 10 G for 23 seconds, eight G for one minute, and four G for 15 minutes.

TEN-G TOLERANCE, it's stated, was limited by impaired vision and extreme difficulty in breathing. Tolerance to backward acceleration, with legs bent and trunk erect, was limited by considerable discomfort from the restraint system, leg pain, and difficult breathing. Twelve G was tolerated for four seconds, 10 G for about 12.

Surfaces contaminated by vapors even in extremely high vacuums

VAPORS EXIST that contaminate surfaces even in vacuums of 10^{-6}-10^{-7} mm, AFOSR research indicates, Maj. Gen. J.W. Sessums, Jr., of ARDC, told recent ARDC-Lockheed symposium on "Surface Effects in Spacecraft Materials." Vapors showed up in studies by Drs. Fraunfelder and Peacock at U. of Illinois in which a mono-atomic layer of radioactive tracer was deposited on metal surface under vacuums. Tracer decays with emission of lightweight particles, so that, after ejection of the particles, the atom has just enough energy to escape from the surface on which it was deposited. In 20 minutes, enough contamination covered the surfaces to block the escape of tracer atoms.

Contamination was thought to be residual air, water vapor, oil, or mercury. Vacuums of at least 10^{-10} mm were needed to eliminate surface contamination.

"THE IMPORTANCE of this result," Sessums states, "is that it points out how difficult it is to carry on really meaningful research on solid sur-

more on page 32
Write in No. 16 on Reader Service Card

Doorway to space With man's metal messengers orbiting beyond the moon, man himself cannot be far behind. His thin-skinned carrier will contain myriad parts and assemblies, each with watch-like precision less tolerant of error than anything before.

Ex-Cell-O's corporate family specializes in this kind of accuracy. For more than 35 years Ex-Cell-O has contributed pioneering ideas, precise parts and assemblies—first to the aircraft industry and now the soaring rocket and missile field. If your program is on the threshold of the Doorway to Space, Ex-Cell-O design, development, and manufacturing may provide the key to the precision needed on the other side of the moon.

XLO
EX-CELL-O FOR PRECISION
EX-CELL-O
CORPORATION
DETROIT 32, MICHIGAN
Aircraft
Division
MAN AND MISSILES FLY HIGHER, FASTER AND SAFER WITH PARTS AND ASSEMBLIES BY EX-CELL-O AND ITS SUBSIDIARIES: BRYANT CHUCKING GRINDER CO., CADILLAC GAGE CO., MICHIGAN TOOL CO., SMITH BEARING CO.
59-35

faces and on the effect of vacuums on the properties of materials such as metals. . . . Much present surface research may turn out to be of little scientific value, and it may also be found that lack of practical information on the properties of clean surfaces will prove dangerous when space flight is attempted, since . . . it may be found that the mechanical properties of clean metals in space will be different from the same metals in air."

Further development and wider use of super high vacuum test methods are necessary, Sessums explained.

COLUMBIUM, tabbed by many experts as the future "work-horse" metal for 2000-2500 deg F, is receiving increased attention. Two new commercially available alloys were announced by Fansteel Metallurgical:

- Fansteel 80 is a Cb-Zr alloy with a melting point of 4350 deg F; a density of 8.6 gm/cm^3; a tensile strength of 47,000 psi (annealed at 70 deg F); a stress to rupture of 18,800 psi for 100 hours at 2000 deg F (argon) and of 11,000 psi for 500 hours at 2000 deg F (argon).

- Fansteel 82 is a Cb-Ta-Zr alloy with a melting point of 4550 deg F; a density of 10.26 gm/cm^3; a tensile strength of 55,000 psi (RT), 29,600 psi (at 2000 deg F in air), or 11,700 psi (at 2400 deg F in air). Stress to rupture is 17,500 psi after 100 hours at 2000 deg F (argon) and 13,500 psi after 500 hours at 2000 deg F (argon).

BOTH ALLOYS can be fabricated at room temperature into complex shapes, Fansteel states. Weldments are ductile, with little or no tendency to fracture in heat-affected zones. Both alloys are available as ingots, forgings, bars, rods, plate, sheet, and fabricated parts.

Battelle Memorial working on system for freeing oxygen from CO_2

OXYGEN STUDY program at Battelle Memorial Institute will run one year. Battelle scientists have been asked to design and develop a practical system for freeing oxygen from carbon dioxide. According to Dr. John F. Foster, who is directing the research program, there are at least three possible solutions: extreme heat to free the oxygen from carbon dioxide, chemical reduction to reverse the basic process of human metabolism, and photosynthesis.

Chemical reduction looks best—on the basis of simplicity and reliability. As outlined by Dr. Foster, a reducing agent would first be used to convert carbon dioxide into solid carbon. Follow-up step would recover the oxygen as a gas.

PHOTOSYNTHESIS has not been ruled out. But, as Dr. Foster points out, it seems improbable that a practical system could be developed as quickly as a chemical reduction process. Use of extreme heat to promote thermal decomposition seems to be the least practical of the three approaches because of poor efficiency and extreme equipment weight.

WADC specs for oxygen system were set up by the Aero Medical Lab. System must be able to process carbon dioxide at a rate that will provide oxygen for one or two men over periods of one month to three years. It must be able to operate efficiently in an atmosphere only about one-third as dense as the earth's at sea level. Since power will be at a premium aboard a space vehicle, the system must operate on a minimum of electric power and heat energy either singly or in combination. Lastly, the system must not depend in any way upon the force of gravity.

Compact repackaging is primary modification on H-1 Saturn rocket

FIRST H-1 LIQUID rocket engine to be used in clusters of eight for the first stage booster of the Saturn space vehicle has been delivered to ABMA. Modifications of existing Thor and Jupiter engines to arrive at the new 160,000-lb thrust H-1 consist primarily of repackaging components for compact grouping within the booster frame. Turbopump, for example, is now slung side-saddle on the thrust chamber instead of on top of it.

•

LOOK FOR a strong push by solid propellant manufacturers for development of a 1,500,000-lb thrust solid engine to parallel or even replace the Army's Saturn cluster or the Rocketdyne 1,500,000-lb thrust LOX-kerosene single-chamber rocket. Development would take about one year for an engine firing for 60-80 seconds, say engineers. Two years would be needed for one burning 120 sec.

New methods would probably have to be de-

more on page 34

The Navy's Versatile Vigilante

... an all-weather attack weapon system with unlimited talents for limited war

Versatility means the ability to do several things well —but frequently not to excel in any one of them.

Not so with the Navy's new A3J Vigilante. It can perform a wide variety of missions — yet its sharply increased performance in *each* would justify building it as a *single-purpose* airplane.

This is the kind of versatility that hurdles the high cost of today's 75-percent-electronic weapon systems... provides the right muscle for every mission... turns minimum budgets into maximum air power.

With Vigilantes aboard its carriers, the Navy will have globe-ranging power to control limited war — from brushfire to tinderbox.

For the Vigilante will deliver any weapon — bomb or missile, conventional or nuclear — day or night, in any weather, at any attitude, from any altitude, a full thousand miles from its carrier. No target can hide from its radar eye. It can be used as a rapier in limited war... as a bludgeon in all-out conflict.

The Vigilante is now in flight evaluation for the Navy. Designer and builder: the Columbus Division of North American Aviation.

THE COLUMBUS DIVISION OF NORTH AMERICAN AVIATION, INC.

Columbus, Ohio

veloped to protect the rocket throat and nozzle (either by auxiliary liquid convection or sweat cooling).

LIQUID HYDROGEN is being produced in large-scale quantities for use as a high energy propellant. In combination with liquid oxygen, it offers an increase of about 40 per cent in thrust over present propellants. It will give about 15 per cent more thrust than boron fuels.

Liquid hydrogen will be used in upper stages of missiles and space vehicles as well as in nuclear engines. Linde has a contract to supply liquid hydrogen for the second-stage rocket on Project Centaur, designed to put a five-ton satellite into orbit around the earth.

Air Products and Stearns-Roger will supply the hydrogen for a nuclear rocket development program. The liquid hydrogen will be pumped through an experimental reactor core.

BIG PRODUCTION PROBLEM was to develop a large-scale catalytic processing technique to convert liquid hydrogen from an unstable to a stable form for safe storage and transportation. Refrigeration problem of getting down to —460 deg F was solved by the use of specially developed hydrogen turbo-expanders.

Martin develops "workable" beryllium sheet for structural fabrication

"WORKABLE" BERYLLIUM sheet material has opened up new design possibility in basic airframe structures. Production techniques were worked up by Martin's Baltimore Division in cooperation with Nuclear Metals of Concord, Mass. Result is a sheet material that possesses homogeneous properties suitable for structural fabrication

In the past, all characteristic forms of beryllium (castings, forgings, rolled sheet, etc.) have shown non-uniform properties and brittleness akin to that of glass—mainly, it was asserted, because of planes of weakness in the metal's metallic crystal. Problem was solved by controlling both the crystal size and orientation during fabrication.

BERYLLIUM LIMITATIONS still exist, though. The new sheet material can be formed or bent only within a finely defined band of hot-forming temperatures. At present, it can be joined only with fasteners and cannot be fusion-welded. For extrusions, forgings, and rolled sheet forms, Martin tests indicate that all continue to yield crystal orientations that result in the familiar brittleness.

M-H MIG guidance to be used in third stage of NASA's Scout booster

NASA'S SCOUT satellite vehicle will use a Minneapolis-Honeywell MIG guidance system in the third stage. M-H will subcontract a hydrogen peroxide control system for the second and third stages. Small jets will provide pitch, jaw, and roll control.

SOLID ROCKETS with 50 million lb thrust are feasible, says Dr. H. W. Ritchey, of Thiokol. Propellants would have to be cast in place at the launching site, but techniques to do this have already been developed. According to Dr. Ritchey, the rocket could be over 50 ft in diameter and limitless in length.

BORON FUELS still look best for aircraft, since they provide as much as 30 per cent more range than regular fuels. Liquid hydrogen is about one-tenth as dense as regular jet fuel, which means it takes up ten times as much space. The extra 40 per cent boost thrust it offers over regular fuels doesn't make up for the difference in volume.

Aerodynamic forces used by Avro flying saucer

ARMY FLYING SAUCER prototype being designed by Avro in Canada has reached the flight test stage. Unlike flying platforms or ducted fan vehicles, the Avro design uses aerodynamic principles rather than brute force to stay aloft and maneuver.

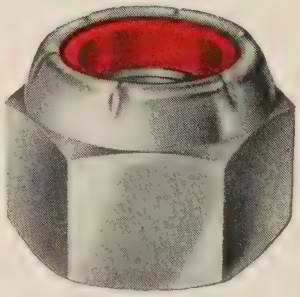
Army has spent more than $5 million on the project in the last three years. Vehicle will be used for low-level tactical flights.

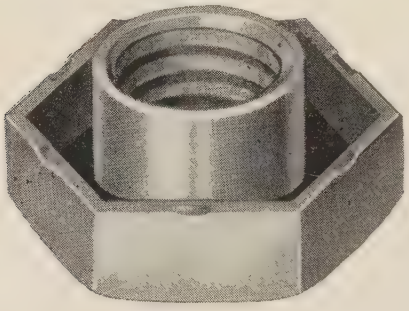
MINIATURE BEARING shielding design, introduced by New Hampshire Ball Bearings, reduces gap between shield and inner ring to 0.002 in., or less than one-third of previous shielding. Result, says the company, is that it can reduce by as much as 70 per cent the size of dirt particles that can get into the bearings.

FOR COMPLETE COVERAGE
OF AIRCRAFT AND MISSILE
FASTENER REQUIREMENTS...

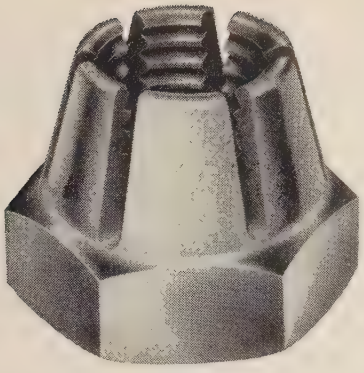
Only ESNA® offers all three locking devices

The Red Nylon Locking Collar for maximum performance under severest conditions of vibration, impact, re-use . . . to 250° F.





The Offset Locking Oval for thin-walled, lightweight, miniaturized fasteners . . . 550° F. and 900° F.



The "Z" or Locking Beam standard of the engine industry for high performance at very high temperatures . . . to 1300° F.

Fit the fastener to the application from the only complete line of self-locking fasteners

ELASTIC STOP NUT CORPORATION OF AMERICA

It takes more than one locking device to cover the specialized requirements of the aircraft and missile industries. One of the three devices offered by ESNA . . . and only ESNA . . . is sure to have the required qualities for each specific application.

That's half of ESNA's story. The other . . . and equally important half . . . is the tremendous variety of special shapes and sizes available with each locking device. Whatever your fastening requirements, there's an Elastic Stop nut designed to do the job. Mail in the coupon for design information on the full line . . . or recommendations for your particular fastening requirements.

Dept. S28-750, Elastic Stop Nut Corporation of America
2330 Vauxhall Road, Union, New Jersey

Please send me the following free fastening information:

☐ Visual index: A complete pictorial representation of all standard Elastic Stop Nuts.

☐ Here is a drawing of our product. What self-locking fastener would you suggest?

Name_____ Title_____

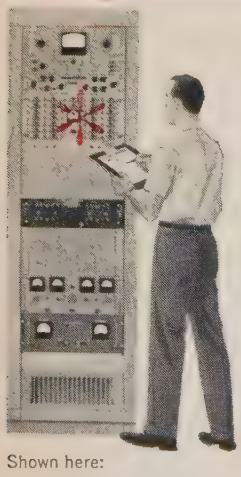
Firm_____

Street_____

City_____ Zone_____ State_____

Write in No. 17 on Reader Service Card at start of Product Preview Section

and there will be no technical hold charged to Arnoux!



Shown here:
portion of Arnoux-built
telemetry-receiving station.

No technical hold ever resulted because of an Arnoux Telemetering Decommutation System (TDS)...none has ever been returned for factory attention. Routine, minimal field-support calls have kept each unit functioning efficiently and accurately. Engineers prefer the TDS because it's actually possible to "adjust-in reliability".

✻The Arnoux TDS accepts all PAM & PDM IRIG inputs...is modular, compact, small...built-in calibration...any channel easily replaced with standby plug-in units...independent linearity within ±½% of full scale...long-term level drift within ±½%...no errors due to SCO center-frequency drift or discriminator dc output-level drift or tape-playback speed variations...no heating problems...simple, novel circuitry. BULLETIN 800b.

ARNOUX CORPORATION
11924 W. Washington Blvd. • Los Angeles 66, Calif.

ARNOUX
PHONETICALLY, SAY ARE NEW
DECOMMUTATORS

Write in No. 18 on Reader Service Card at start of Product Preview Section

calendar

July 13-14—10th Anniversary Meeting of Airlines Electronic Engineering Committee, Ambassador Hotel, Los Angeles, Calif.

July 16-17—Third biennial joint meeting, Radio Technical Commission for Aeronautics and Los Angeles Section of the Institute of Radio Engineers, Ambassador Hotel, Los Angeles, Calif.

July 30-31—Sixth Annual Symposium on Computers and Data Processing, Denver Research Institute, Stanley Hotel, Estes Park, Colo.

August 4-5—Second Annual Western Regional Meeting, American Astronautical Society, Ambassador Hotel, Los Angeles, Calif.

August 5-7—William Frederick Durand Centennial Conference on the Problems of Hypersonic & Space Flight, Stanford U., Stanford, Calif.

August 9-12—Heat Transfer Conference, American Society of Mechanical Engineers & AICE, Univ. of Conn., Storrs, Conn.

August 10-13—Society of Automotive Engineers, National West Coast Meeting, Hotel Georgia, Vancouver, B. C.

August 17—First National Ultrasonics Symposium, IRE, Professional Group on Ultrasonics Engineering, Stanford Univ., Stanford, Calif.

August 18-21—Western Electronic Show & Convention, IRE, Cow Palace, San Francisco, Calif.

August 24-26—Gas Dynamics Symposium, American Rocket Society, Northwestern Univ., Evanston, Ill.

August 24-26—Institute of the Aeronautical Sciences' National Specialists Meeting, Symposium on Anti-Submarine Warfare, (classified) San Diego, Calif.

August 27-28—International Commonwealth Spaceflight Symposium, Church House, Westminster, London, England.

August 31-September 5—10th Annual Congress, International Astronautical Federation, Church House, Westminster, London, England.

September 1-2—Conference on Physical Chemistry in Aerodynamic & Space Flight, Air Force Office of Scientific Research and General Electric Co.'s Missile & Space Vehicle Dept., Univ. of Pennsylvania, Philadelphia, Pa.

September 2-4—1959 Cryogenic Engineering Conference, Univ. of California, Berkeley, Calif.

September 3-6—National Convention & Aerospace Panorama, Air Force Assn., Exhibition Hall, Miami Beach, Fla.

September 9-11—Sixth Midwestern Conference on Fluid & Solid Mechanics, AFOSR/Directorate of Aeronautical Sciences, Office of Naval Research; National Science Foundation, Dept. of Aeronautical Engineering, Univ. of Texas, Austin, Texas.

September 16-17—Western Regional Meeting on Frontiers of Science and Engineering, Los Angeles, Calif.

PICTURE CREDITS: Cover, p. 5—S/A (Meyerriecks); pp. 42-45— AiResearch Mfg.; pp. 40-41— General Electric; pp. 48-51—Fansteel Metallurgical; pp. 57-59—S/A, North American Aviation; pp. 61-73—Carter; pp. 85-90—NBS, Iron Age; pp. 93-103—General Electric; pp. 105-109—Linde; pp. 120-123—Electronic Specialty; pp. 143-150— Raytheon Mfg.

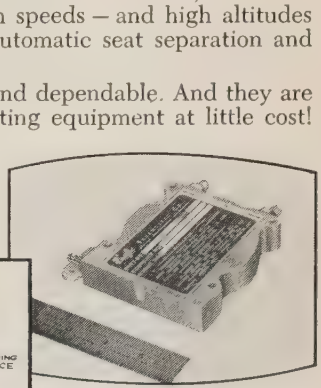
To increase safety ... *at* ***all altitudes*** ...

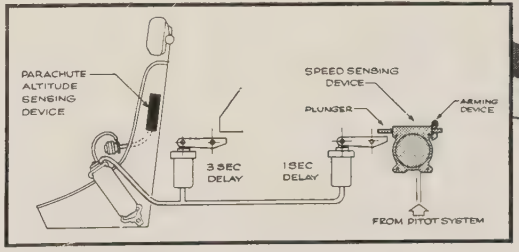
Pacific's *new* EMERGENCY ESCAPE DEVICES *solve Automatic Sequencing Problem!*

When a pilot ejects at high speeds, seat-man separation is delayed two seconds to prevent injury and parachute tearing. *However, this delay at low altitudes, where ejection is rarely made at extreme speed, may prevent full parachute opening before the pilot hits the ground!*

To reduce this delay and to increase pilot safety at low altitudes, Pacific Scientific has developed a *Speed Sensor* and a *Parachute Release Actuator* for the Air Force that cuts the two second delay to one second – and deploys the parachute in less than 1/10th second! In addition, these two devices permit a three second delay at high speeds – and high altitudes – thus providing the correct sequence of automatic seat separation and parachute deployment under any condition!

Both devices are unusually simple, rugged and dependable. And they are designed to permit easy installation on existing equipment at little cost! This is *the type of reliable engineering ingenuity Pacific can offer your company ... the capability to resolve perplexing problems with practical, simple solutions.*





Pacific's miniature Speed Sensor (above) and Parachute Altitude Sensing Device (indicated in diagram) are the key elements in this new Emergency Escape System.

If your problem is in controls, instruments, or safety equipment, discuss it with Pacific. Do so today!

PACIFIC SCIENTIFIC COMPANY
P. O. Box 22019, Los Angeles 22, Calif.
SAN DIEGO • SAN FRANCISCO
SEATTLE • PORTLAND, ORE.
ARLINGTON, TEXAS

Pacific TRADE MARK

REPRESENTATIVES:
In the Eastern U. S.: Aero Engineering Co., Mineola, L. I., N.Y.
In Canada: The Garrett Manufacturing Corp., Toronto, Ontario

CREATIVE MANUFACTURING AND DEVELOPMENT OF AIRBORNE CONTROLS.

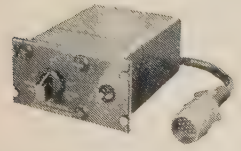
Write in No. 19 on Reader Service Card at start of Product Preview Section

THE MARK OF QUALITY

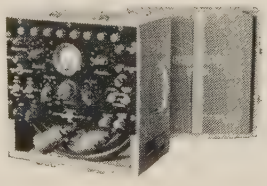
BARBER COLMAN

Can you use these capabilities and facilities on your missile projects, too?

For the contractor facing certain missile research and development problems, substantial aid can very likely be enlisted right here. At Barber-Colman Company you find the engineering excellence, the long years of experience in the aircraft controls field, and the precision production facilities so vital to component perfection. To put all this to work on your problems, write direct, or call the Barber-Colman engineering field office nearest you.

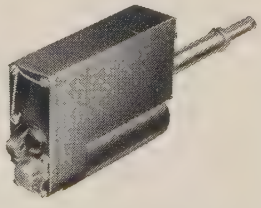


TEMPERATURE AND POSITIONING CONTROLS

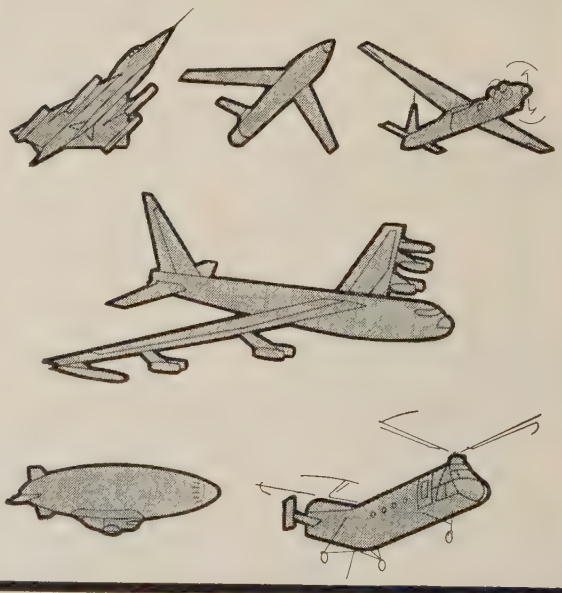


GROUND TEST EQUIPMENT

VALVES



ACTUATORS



EQUIPMENT SUPPLIERS FOR VARIOUS TYPES OF AIRCRAFT AND MISSILES!

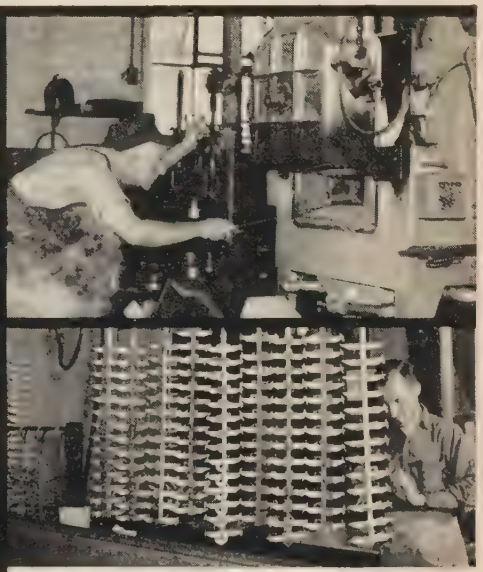
Building controls for aircraft is nothing new to Barber-Colman Company. Since the mid-thirties, we have been in the business of engineering and producing electro-mechanical control systems for all these categories of air vehicles: manned airplanes — military, commercial, and business types . . . lighter-than-air . . . helicopters . . . drones . . . and, more recently, missiles. Major experience has been centered on such products as valves . . . actuators . . . temperature and positioning controls . . . ground test equipment. Which areas of this experience would be most helpful in the development of your projects, either today or for the future?

UNIQUE, COMPREHENSIVE MANUFACTURING FACILITIES

Complete follow-through from product development to product application. . . . is standard procedure on every piece of aircraft equipment that bears the Barber-Colman mark. Every step of engineering, manufacturing, and testing is performed under the complete control of "one maker." For example, control system components such as motors, relays, gears, pinions, valves, sensing elements, and the like, are of Barber-Colman Company's own manufacture. Metals are analyzed, treated, and finished in our own departments. Machining and gear hobbing are performed on machines of our own make. A few typical scenes from the vast Barber-Colman development and manufacturing areas are shown below.

GINEERING —Barber-Colman Company h its highly experienced staff of engineers able to bring you specialized assistance any stage of your controls development gram.

METAL-TESTING—Skilled technicians in well-equipped chemical and metallurgical laboratories maintain constant surveillance of materials . . . analyze and determine exact heat-treatment needed.



HEAT-TREATING AND METAL-FINISHING—Batteries of furnaces, ovens, and immersion pots are at hand for all types of heat-treating. Finishing includes anodizing, alodizing, sand-blasting, vapor-blasting, electropolishing.

ROM PROTOTYPE TO PRODUCTION—Barber-Colman Company aintains its own fully equipped and expertly staffed department complete manufacture of prototypes (top view). Lower view ows a section of the actuator production operation.

TESTING FACILITIES—To ensure that all products meet performance and environmental requirements, Barber-Colman Company is equipped with the most advanced analysis, simulation, and test facilities. Above views show typical test setups.

BARBER-COLMAN COMPANY

Dept. S, 1423 Rock Street, Rockford, Illinois

ineering Sales Offices: 191 Hillside Ave., L.I., N.Y. • Alexander & Eames Sts., Framingham, Mass. • 190 E. Glenarm St., Pasadena 2 • Boeing Field, Seattle 8 • Ridglea State k Bldg., Fort Worth 16 • Machinery & Equipment Sales, 1012 Cathedral St., Baltimore • Rockford, Ill. • Rousseau Controls Ltd., 640 DeCourcelle St., Montreal 30

Write in No. 207 on Reader Service Card at start of Product Preview Section

Rising demand for technical managers

Equipment isn't the only thing that often has an entirely new look these days in the aerospace industry—there are new breeds of people, too. Most important among these are, without any doubt, the so-called "technical managers." Trained as engineers, they fill jobs that are mostly administrative—though with a strong technical flavor. This article is the first in an extended series devoted to the problems of the technical manager.

by Robert M. Loebelson, Associate Editor

IN THE WAKE of the technological revolution in the aerospace industry over the past few years, more and more management decisions have become a matte of technical judgment. Every firm in the industr therefore has been trying to find or develop personnel with both technical and administrative qualifications. Although the current problem is really an extension oi headaches that have plagued airframe and engine producers for many years, the breakthroughs in so many areas of interest to the companies that produce aircraft, missiles, and spacecraft have come so fast that the demand for technical managers far exceeds the supply.

Some companies try to avoid outside recruiting of technical managers as much as possible. At Aerojet-General, of Azusa, Calif., for instance, L. L. Thompson and Frank Young of the personnel department put it this way:

"We have come to the conclusion it rarely pays to go outside the company when an executive niche has to be filled. You end up hiring one good man, but probably you usually lose two in the process."

Yet a SPACE/AERONAUTICS survey shows there is no firm in the industry that will state flatly that it has not "stolen" qualified men from other organizations. All companies apparently prefer to promote from within. But they often find that the man they need for a specific technical management position cannot be found in their own company. At times, they know of an individual with just the qualifications they want on the payroll of a competitor—and try to hire him away. On other occasions, they use the services of executive placement organizations.

One management counseling that has done a substantial amount of work in the technical management area is Herbert Halbrecht Associates, of Chicago. Its president, Herbert Halbrecht, reports:

"There is an increasing demand for project and group leader engineers, as well as engineering supervisors and managers. These are at the $10,-15,000 levels generally, with a rather noticeable increase in the $12,000-and-up range."

Halbrecht attributes the growing demand for supervisory personnel to several factors:

- Although most firms have been compelled to take good engineers and put them into administrative and project leader spots, the results have generally not been entirely satisfactory. Only relatively few good engineers who have the technical competence to direct the engineering side of a project also have the administrative and managerial competence to administer budgets, lead and supervise men, plan and forecast for the future and generally act as management personnel.
- One of the most difficult problems in this connection is the tremendous turnover of engineers at the $8000-15,000 level. Industry, according to Halbrecht, seems to be doing little to combat this trend. The situation is made worse by the fact that the demand for engineers outstrips the supply, which makes it almost impossible for many personnel and engineering executives to be as discriminating as they would like

Wider Role for Engineers

"The role of scientists and engineers in management decisions must go beyond an appreciation of technological feasibility and also be concerned with such factors as budgets, facilities costs and requirements and the numerous financial considerations involved in weapon projects.

"As soon as our scientists and engineers become aware of these factors, their contribution will be increased and, with that increased contribution, our policy decisions will be greatly improved, our national security strengthened and the nation's welfare advanced."—Orval R. Cook, president, Aerospace Industries Association.

to about men who have had too many jobs in a brief time.

• Many of the men who aspire to management positions have never had the training they ought to have for such jobs. Major colleges and universities have recognized this deficiency and are trying to overcome it by requiring all engineering students to take liberal arts and social sciences in their first two years (as well as pre-engineering courses). This regulation is designed to provide engineers with a better outlook and enable them to cope with general management problems.

• Halbrecht maintains that most of the aerospace companies provide additional educational benefits in the technical fields but do very little to encourage engineering personnel to take courses in the social sciences, humanities, or business administration. "Paradoxically," he adds, "the engineer with a high level of technical competence who has also gotten a degree in business administration is very highly sought after at these management levels."

The Chicago management consultant maintains that too many engineers, simply because they are technically competent, assume they are qualified for managerial positions. "Unfortunately," he declares, "when they are given such administrative responsibility out of necessity, many of them do not perform as well as is hoped for."

Weapon system know-how is sought

Halbrecht has detected another trend. Considerable emphasis, he reports, is being placed on procurement of engineering managers with experience on complete weapon systems instead of specific pieces of hardware. "We have had approximately a 300 per cent increase in demand for personnel with experience like this, primarily at levels of $17,-25,000 a year," he states.

Halbrecht emphasizes that, in his experience, "there are not that many top level men in the country who are available and who have the understanding and the experience necessary to do evaluation or complete systems." He predicts the demand for technical managers of this caliber will increase as the Pentagon is placing greater emphasis on the use of weapon system contractors.

The demand for engineers with administrative capabilities is also affecting the recruitment practices in the aerospace industry. One firm active in this field is Keelor & Stites, of Cincinnati, Ohio, which has been handling the industrial advertising for such firms as General Electric's Flight Propulsion Department, Cincinnati Milling Machine's Hydroform Division, Cincinnati Lathe & Tool, and Cincinnati Gear. Says John T. Nolan, Jr., president of Keelor & Stites:

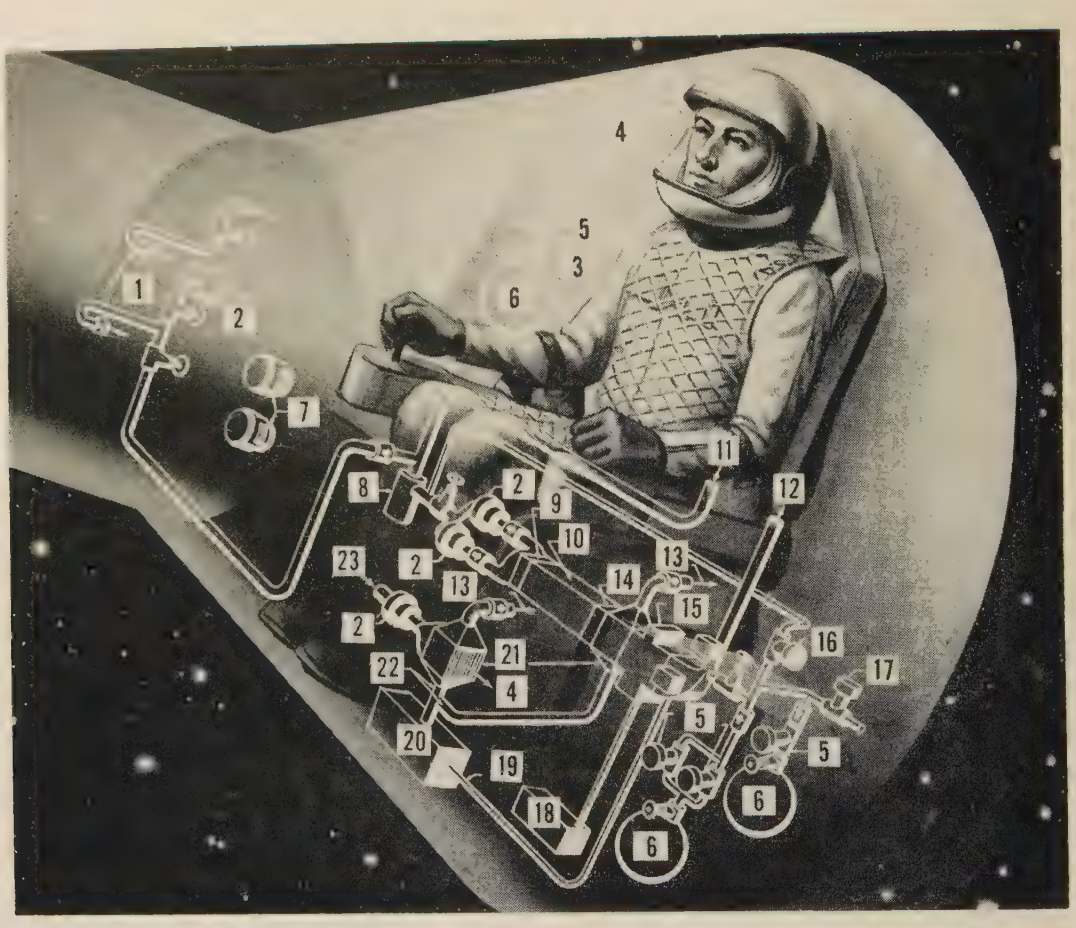
"Engineers as a group are negatively oriented to most common kinds of advertising at the personal level. They are quite willing to read a nuts-and-bolts ad describing a lathe, and accept or reject the item for their firm on the basis of the advertising copy, provided the copy is clear and consistent." But, he adds, "at the personal level—where a change in their own lives is involved—it's quite another thing. To gain readership of recruiting messages, the best procedure is to say something simple in the headline that will interest the engineer professionally, and then follow up with logically developed body copy."

The engineer who wants to move up into a technical management position should consider all the factors that might result in such a promotion. Obviously, a thorough technical knowledge of a single aerospace discipline will not suffice. The ability to handle men, a knowledge of the way the defense budget is developed, familiarity with the competitive situation, an understanding of international development, and many other factors are necessary attributes of the technical manager!—End

Salaries

Electrical engineers placed in administrative positions in the aerospace industry by a Chicago management counseling firm start at the $8000-10,000 level. Larger and medium size firms usually offer the higher figure, smaller companies tend to offer about $8000.

Geography has very little to do with the salaries that technical managers are offered. Airframe and electronics companies on the West Coast and in Southwest and Southeast generally seem to offer 5-8 per cent less for comparable positions than firms in the New York area and the Midwest. New England companies are somewhere in between.



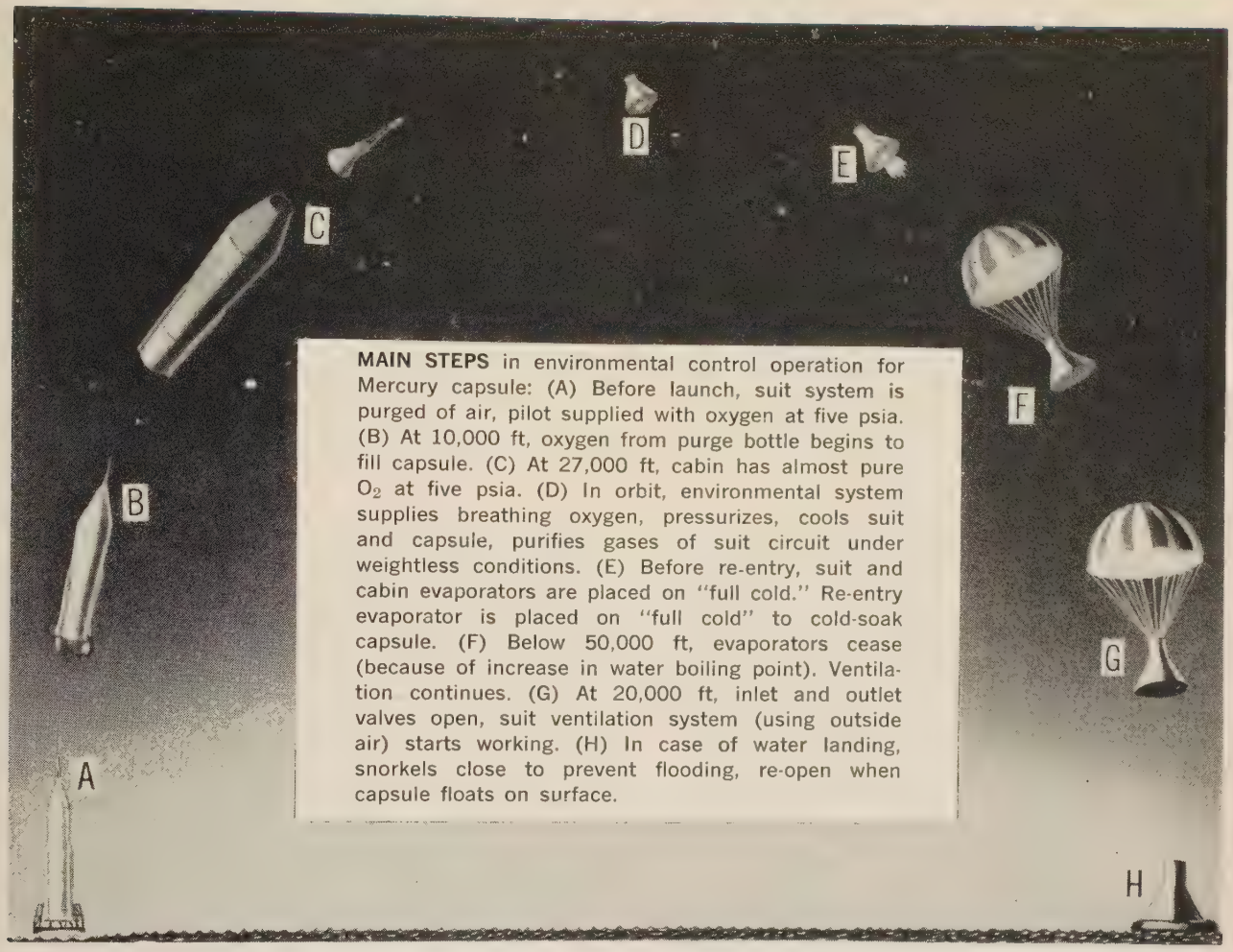
Environmental system

for Mercury capsule is simple, rugged

It may seem at times as though simple, straightforward airborne systems were a thing of the past. But they aren't—as is shown by this exclusive report on how the air conditioning and pressurization rigid specs of the Mercury capsule were met by AiResearch-Los Angeles, designers and manufacturers of the environmental control system.

by Irwin Stambler, Associate Editor

SIMPLICITY AND FAIL-SAFETY are the outstanding characteristics of vital air conditioning and pressurization system that will provide the artificial environment for this nation's first astronaut. Conceived by the manufacturer of NASA Project Mercury manned orbital capsule, McDonnell Aircraft, and Garrett Corporation's AiResearch Mfg. Div. of Los Angeles 9851-9951 Sepvulveda Blvd., the system is designed to operate under launch and re-entry conditions and in an elliptical orbit with a perigee of 105 miles and an apogee of 120 miles, involving a range of temperatures from —20 to 200 deg F and a zero-G (weightless) environment.



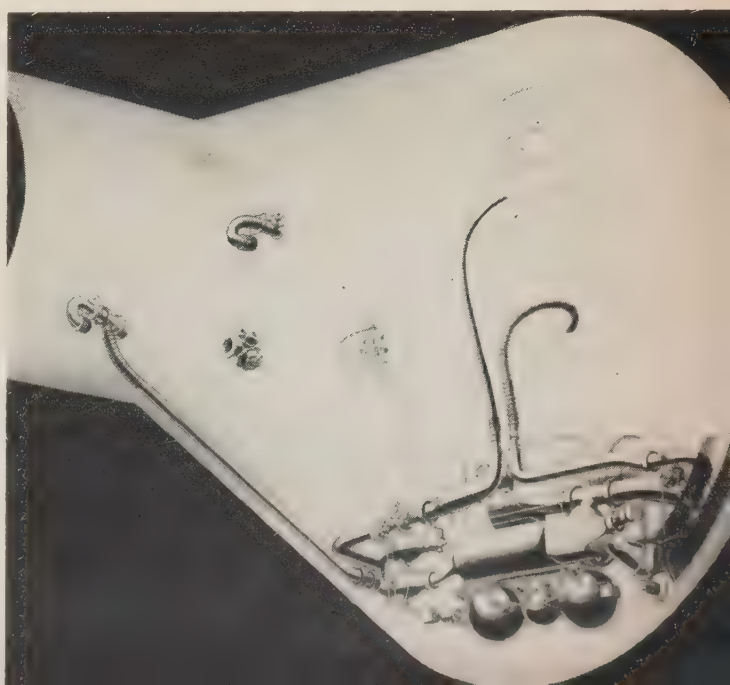
MAIN STEPS in environmental control operation for Mercury capsule: (A) Before launch, suit system is purged of air, pilot supplied with oxygen at five psia. (B) At 10,000 ft, oxygen from purge bottle begins to fill capsule. (C) At 27,000 ft, cabin has almost pure O_2 at five psia. (D) In orbit, environmental system supplies breathing oxygen, pressurizes, cools suit and capsule, purifies gases of suit circuit under weightless conditions. (E) Before re-entry, suit and cabin evaporators are placed on "full cold." Re-entry evaporator is placed on "full cold" to cold-soak capsule. (F) Below 50,000 ft, evaporators cease (because of increase in water boiling point). Ventilation continues. (G) At 20,000 ft, inlet and outlet valves open, suit ventilation system (using outside air) starts working. (H) In case of water landing, snorkels close to prevent flooding, re-open when capsule floats on surface.

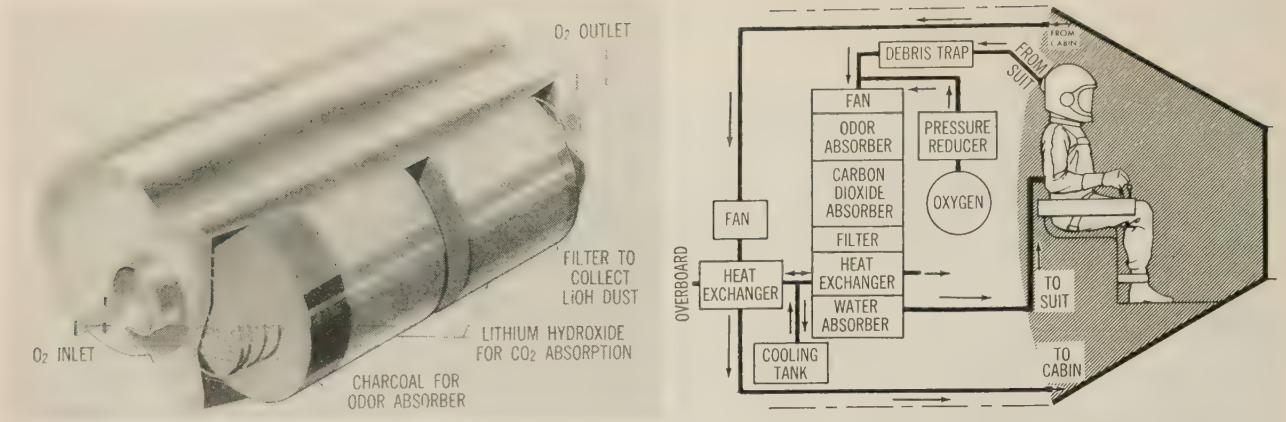
MERCURY ENVIRONMENTAL system (top left and below right): (1) snorkels, (2) fans, (3) purge system, (4) to cabin, (5) pressure reducers, (6) oxygen, (7) pressure relief valves, (8) debris trap, (9) odor absorber, (10) CO_2 absorber, (11) from suit, (12) to suit, (13) overboard, (14) filter, (15) H_2O absorber, (16) demand regulator, (17) pressure regulator, (18) H_2O tank, (19) tank pressure line, (20) cooling tank, (21) heat exchangers, (22) H_2O lines, (23) from cabin. Re-entry system is not shown.

A good example of the fail-safe approach is the provision of what are actually two environments in the capsule: (1) the pilot's suit is pressurized by oxygen at five psia, and (2) the capsule itself, once it is in orbit, has an essentially pure-oxygen environment maintained by a pressure regulator (also at five psia). One advantage of pressurizing the capsule, AiResearch project engineer E. H. Olling told SPACE/AERONAUTICS, is that a redundant breathable atmosphere is provided.

Gaseous oxygen for the overall system is stored at 7500 psi in three bottles under the pilot's seat. One of these is the normally used oxygen bottle and provides

more on next page





ESSENTIAL components of environmental system (center left) devised by McDonnell and AiResearch for the Mercury capsule include odor and CO_2 absorber with a stainless steel case and plastic screens, suit (far left) circuit compressor (center right), and water separator (far right), in which oxygen enters at (1) as well

enough oxygen for a 28-hour mission, allowing for oxygen leakage in the capsule. A second bottle provides a 26-hour supply of oxygen to be used in case of emergency. The third, smaller bottle is for the launch purge system.

The three bottles are filled through disconnect fittings on the ground just before launch. The system shutoff valves are opened just before the hatch is closed and the pilot sealed in.

The second bottle normally is automatically fed into the circuit when the first bottle is exhausted, to give a maximum 52-hour endurance. In an emergency mode, the second bottle feeds through a constant-flow regulator at a rate in excess of the pilot's needs.

The pilot's suit circuit begins operating as soon as the shutoff valve is opened. The oxygen goes through two high pressure reducers, which lower its pressure from 7500 to 100 psia. The oxygen then goes through a check valve that can be closed if necessary to maintain the pressure in the suit circuit. A demand regulator in the suit circuit reduces the 100-psia pressure to five psia. It lets only as much oxygen enter the circuit as is needed to maintain the correct supply to the pilot and the system.

Oxygen from the bottle supply is combined with the flow coming from the pilot's suit after the latter has passed through a solids trap that removes nasal secretions, hair, etc. (see *Diagram*). The flow passes through a relief valve that insures line pressure doesn't exceed 5.25 psia.

Dual compressors are provided

The flow passes through a shutoff valve that can be manually operated by the pilot in case of emergency. It then goes to a direct-drive, electric-motor-powered compressor developing 11.5 cfm at 10 in H_2O (see *Schematic*). A standby compressor is provided and switches on automatically if the other unit fails. A pressure switch senses the pressure across the compressor and, if the pressure falls below a certain level, turns the compressor off.

From the compressor, the flow goes to an odor and CO_2 absorber (see *Schematic*). This unit is in the form of two intersecting cylinders to meet the strength requirements for the pressure differential and still be as light as possible. Here activated charcoal removes odors and lithium hydroxide (LiOH) filters out all but four millimeters of CO_2.

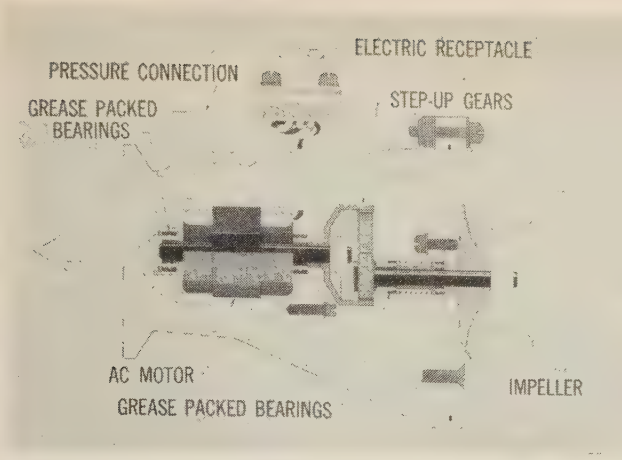
There's a gap between the two LiOH sections of the canister. It lets the flow reestablish itself and prevents "channeling", which occurs when a flow uses only the chemicals on the periphery of a filter. Fine-mesh plastic screens are permanently attached to the canister at the gap ends of the LiOH. Springs at the ends of the canister force the filter sections against these screens to keep the charcoal and LiOH tightly packed, so that all the granules remain in place. Spring loading is also intended to keep the periphery of the filters in contact with the canister to prevent the flow from going around this periphery.

Another filter downstream of the second LiOH section catches LiOH dust particles, since these can be irritating to the pilot. Mesh plastic screens, are inserted between the charcoal and LiOH and at the spring-loaded end sections of the filters. They are plastic because the LiOH is corrosive to some metals. For the same reason, the canister is stainless steel.

Plate-fin heat exchanger used

The oxygen next goes to a plate-and-fin heat exchanger, where it's cooled to 40 deg F. Additionally, moisture in the oxygen from perspiration or the normal breathing process is condensed into water droplets. Cooling is needed because the warm air from the suit is heated up further by energy dissipation in the compressor and by the heat liberated in the chemical reactions of the CO_2 absorber. Water evaporation is used for cooling. Heat transfer from the oxygen causes the water to boil. (At essentially zero pressure in orbit, water evaporates at less than 32 deg. F.) The oxygen then goes to a water separator, where the water droplets are collected in a sponge.

The capsule itself starts out filled with air. As it ascends, air flows out through the cabin pressure relief



as at pneumatic inlet (2) and emerges at (3) as well as at (4), from where it goes to the pneumatic actuator. Water emerges at (5). Other important evaporator parts are a sponge (6), a return spring (7), a guide rod (8), and a water check valve (9). Collecting and separating positions are shown at (10) and (11), respectively.

valve (also dualed for reliability). At 10,000 ft altitude, the purge bottle system is actuated by a regulator and begins to force out the rest of the air. At 27,000 ft, the valve closes, leaving an almost pure oxygen atmosphere at five psia. (At higher altitudes, the cabin pressure relief valve is set to relieve at 5.5 psia.)

Third circuit needed for re-entry

The capsule atmosphere recirculating system, which operates at altitudes over 27,000 ft, consists of a fan and an evaporator. The fan, which draws in cabin air, is a 2-2½-in. axial-flow unit. Its intake is covered with a screen—if the pilot dropped a pencil in the zero-G situation in orbit, the pencil would float and eventually be drawn into the fan if there were no screen. The oxygen goes through the same type of evaporator as in the suit circuit and is recirculated to cool both capsule environment and equipment.

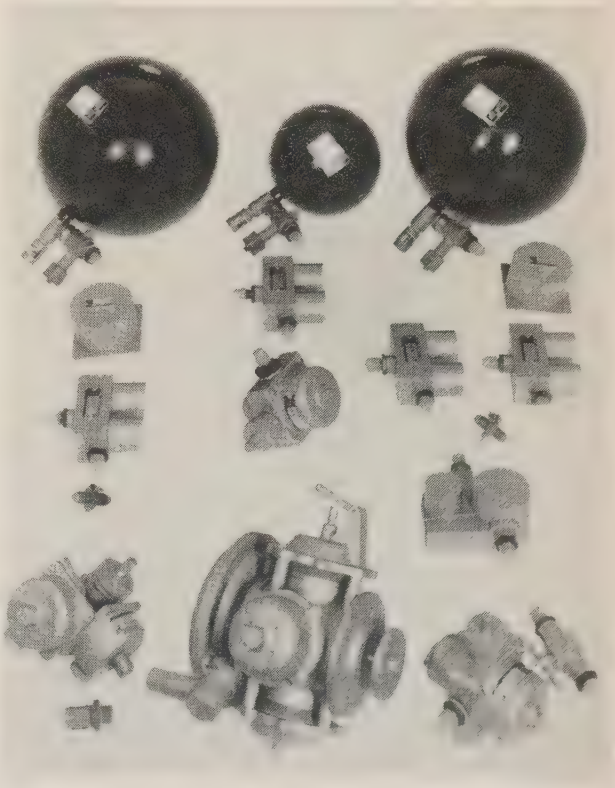
During re-entry, the heat loads get very large. Therefore, a third circuit with a fan and evaporator is needed in addition to the normal cabin evaporator. The re-entry evaporator has 4-5 times the capacity of the normal unit. It has only one pass (with no superheating, since there's no exit duct freezing problem). During re-entry, the cabin pressure relief valve opens and lets in cooling air.

During descent at under 50,000 ft altitude, the boiling point of the water is too high for effective cooling of the pure oxygen by the evaporator. At 20,000 ft, the ventilation inlet and outlet valves, or snorkels, are opened automatically by a barometric control. As they open, they automatically shut off the re-entry and cabin fans. From now until landing, cool outside air is pumped into the pilot's suit circuit and then dumped overboard. If the capsule should land in the water, the water forces will cause the snorkels to close. When the water pressure is removed, the snorkels open again.

In case of malfunction of the primary suit oxygen supply, manually operated shutoff valves can be worked by the pilot to start up the emergency supply (as we've already noted). The flow from the emergency supply then goes through the suit, the solids trap, and out (through a relief valve in the demand regulator) into the cabin.

During ground operation, while there's no cooling available from the water, freon F-114 is pumped into the water inlet side of the evaporator through an umbilical and evaporated. This arrangement takes care of cooling the pilot after the hatch is closed just before launch.—End

MOCKUP of key components for McDonnell Project Mercury environmental control system shows advanced state of system work.



Combustion instability . . .

what are its causes and cures?

If you work on any form of jet propulsion, combustion instability is sure to be one of your most persistent troubles. Though we'll probably never lick it entirely, much can be done to reduce the problem to manageable proportions, as this report shows.

by Kurt R. Stehling, Consulting Technical Editor

HOW propellant impingement can contribute to combustion instability is shown by this model setup in which two small water jets break up typically after impingement.

NO COMBUSTION PROCESS, however simple, is ever completely smooth. Even a candle flame in still air flickers and shows occasional changes of light intensity, as a result of uneven mixing of the air and the paraffin.

The trouble is that combustion by definition depends on the heat-producing reaction of several substances. To regulate the flow, or rate of feed, of these substances so that combustion proceeds without oscillations or at least without any large ones is next to impossible.

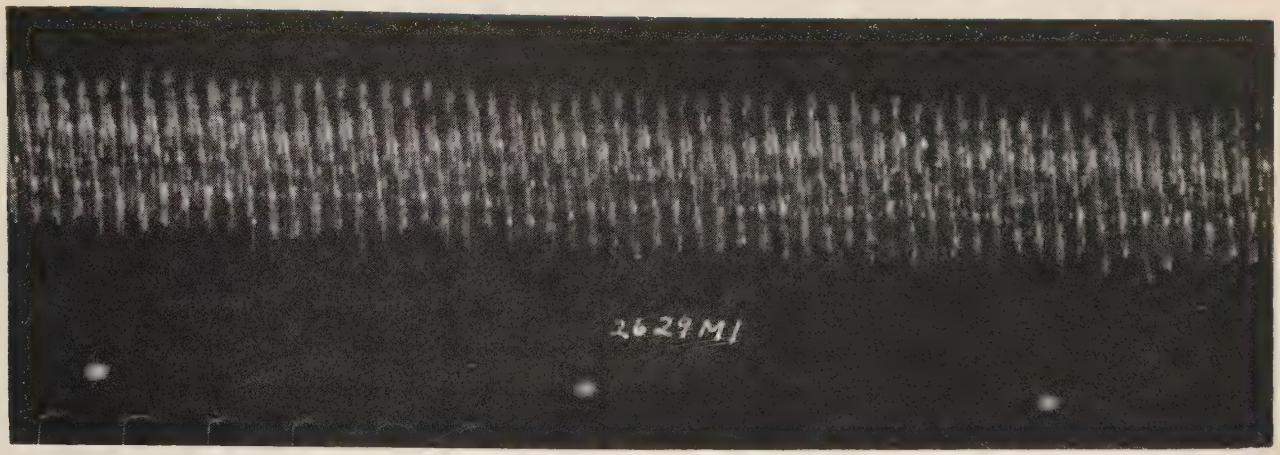
The combustion processes of jet propulsion—in turbojets, ramjets, and rockets—are particularly susceptible to oscillations. Often these oscillations pose no serious problem. But the designer never can be sure in advance that they won't, and so the threat of oscillations is one of his perennial headaches. To qualify as a serious defect and cause "instability", oscillations usually must be severe enough to produce visible or audible changes in the combustion "tone", or sound.

Instability may cause a burnout

The actual harmful effects of combustion instability are:

- swift changes of the thrust level, which produce vibrations in the vehicle in the case of a rocket and occasionally break the engine mountings;
- a large change in heat rejection in the combustion chamber, which leads to the destruction of the chamber liner or to burnout;
- asymmetrical gas flow, which may produce violent side-to-side perturbations in rocket and ramjet exhaust nozzles.

It's obvious that combustion instability can seriously impair the effectiveness of a whole vehicle, even if it does not lead to anything as drastic as burnout or major structural damage—in a missile, for instance, it's enough if combustion is sufficiently unstable to affect some sensitive but vital electronic or



IMPORTANT STEP in rocket combustion instability research was the development some years ago of a thrust chamber with a transparent slit window of quartz by Dr. Kurt Berman and others at General Electric's Malta, N.Y., facility. The GE researchers have been able to photograph and record pressure oscillations within the chamber, as shown here. Berman's findings led him to postulate that small detonation waves can occur in the combustion chamber. This phenomenon can be minimized by careful design, he says.

electromechanical component. Much research therefore has gone into diagnosing the causes of combustion instability and into finding cures for it, especially in the most critical case of rockets.

Actually, there doesn't seem to be any single cause of combustion instability in rockets. It's generally agreed that a variety of factors may cause oscillations:

- a low pressure drop across the injector through which the propellants reach the thrust chamber;
- turbulence set up in the liquid flow through the maze of a rocket's plumbing;
- loose or chattering valve components;
- irregular turbopump operation;
- an adverse relationship between the start of propellant injection into the thrust chamber and the start of combustion—it seems the time lag between these two events should be as short as possible;
- abnormally low chamber pressure;
- a chamber design that has an acoustically resonant mode, permitting the build-up of a particular vibration;
- small perturbations in the propellant injection streams, which as a result impinge erratically.

Engineers have relied on instinct

For many years, propulsion engineers have dealt with combustion instability more or less instinctively by making changes in their hardware. A given case of instability might lead to the successive replacement of a series of suspect valves, to attempts to smooth out the operation of the turbopump, and to increases in the liquid pressure drop through the system—all until the oscillations went away or dropped to an acceptable level.

At the same time researchers—at Jet Propulsion Lab, NASA's Lewis lab, Princeton, and Purdue, for instance—tried to tackle the problem from the theoretical angle. Especially at Princeton and Purdue, attempts were made — with only partial success — to equate ignition lags and combustion instability. Naturally the findings of these researchers were produced under ideal conditions with small rockets, and to what extent they apply to today's giant engines in actual use is doubtful. We can say, though, that shorter ignition lags—achieved through the use of very energetic propellants and special injectors—are helpful in certain cases of combustion instability.

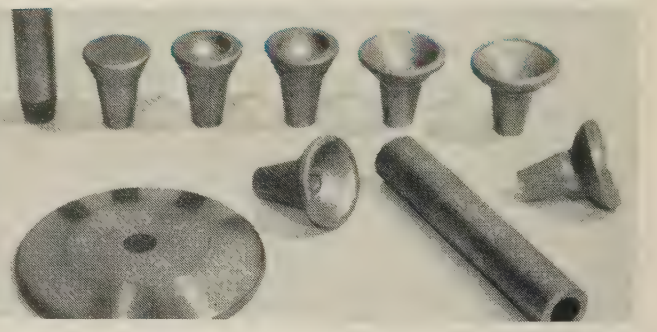
Oscillations occur in two bands

Research has also shown that burning oscillations occur commonly in two bands—around 2000 cps and around 200 cps. The higher frequency oscillations are more likely to be caused by ignition lags and are not always destructive. The lower frequency oscillations, with their higher amplitude, tend to be more dangerous. They can be quenched by increased chamber pressure or, in the case of a solid rocket, by a "bluff" body inserted into the combustion zone.

Plumbing should be carefully selected to forestall noise and vibration, and valves and other flow control components should be water-hammer-free. The holes in injectors should be carefully drilled and aligned to prevent wavering and asymmetric streams.

According to a theory to which Lewis researchers have devoted particular attention, pressurized gases can dissolve in propellants and cause combustion instability. To reduce this danger to negligible proportions, helium, which is relatively insoluble, may be used as the pressurizing medium, or bladders, or low pressurization and turboprops.

When it's the turbopump itself that's causing the oscillations, these can be quenched sometimes or at least sharply reduced by placing flow restrictions in the chamber outlet sides. In ramjets, grids or protuberances in the combustion zone tend to quench the oscillations.—End



TYPICAL TUNGSTEN shapes (left) made by new drawing and spinning methods developed by Fansteel. Above: Steps in tungsten forging are shown by top row of parts. Large X-ray target (lower left) was made from compact that was preformed to the rough shape, sintered, and then forged. Seamless tungsten tube at right was made by hot-extruding

New tungsten know-how

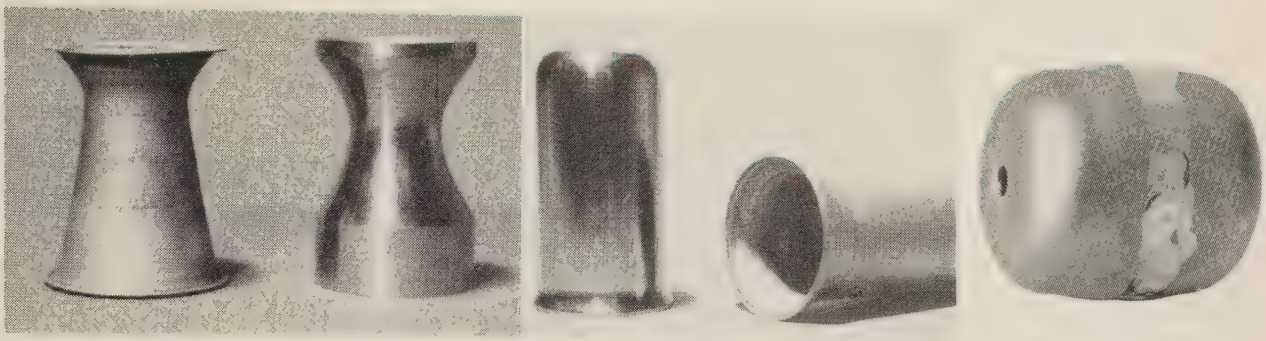
widens design horizons

Recent advances in fabrication have made tungsten one of the promising metals for high temperature designs. This article, based on interviews at Fansteel Metallurgical and Stanford Research Institute, details some of the progress that has been made.

by Irwin Stambler, Associate Editor

TUNGSTEN, which has the highest melting point (6152 deg F) of any available ductile material, promises to solve many of the problems of the space age. For instance, R. H. Thielemann, Chairman of the Metallurgy Dept. of the Physical Research Div., at Stanford Research Institute, Palo Alto, Calif., told SPACE/AERONAUTICS that certain double-base propellants could provide important advances in propulsion if nozzles could be made to withstand the extremely high temperatures these propellants generate.

Ceramics can't stand the heat shock in this range.



REVERSE conical sections (left) spun from rolled tungsten sheet. Center: Tungsten crucibles, with a length of twice the diameter, were spun from wrought sheet. Right: Radioisotope container suggested by Fansteel could be made by gold-brazing two drawn-tungsten cups together.

Tungsten vs Other Metals

	W	Ta	Mo	Nb	Ti	Fe	Be	Cu
Melting point (deg F)	6152	5425	4752	4379	3074	2804	2304	1979
Density (gm/cm^3)	19.3	16.6	10.2	8.57	4.54	7.87	1.84	8.96
Expansion Coefficient (deg F)	2.2	3.6	3.05	4	4.7	6.5	6.8	9.3
Specific Heat (cal/gm/deg C)	0.034	0.0356	0.061	0.064	0.126	0.11	0.425	0.09

Typical Mechanical Properties of Tungsten Forms[1]

	Tensile Strength (psi)	Hardness (Rockwell)
Rod		
0.25 in.	70,000	37C
0.1 in.	150,000	40C
0.05 in.	200,000	44C
Wire		
0.025 in.	225,000	44C
0.01 in.	250,000	
0.005 in.	300,000	
Sheet		
0.04 in.	120,000	44C[2]
0.02 in.	200,000	45C[2]
0.01 in.	300,000	47C

(1) Properties at room temperature for annealed forms with zero elongation in two inches. (2) Converted.

Typical Properties of Tungsten

Atomic number	74
Atomic weight	183.92
Atomic volume	9.53
Density at 20 deg C	0.697 Lb/cu in.
Melting point	6152 deg F
Linear coefficient of expansion per deg F at 70 deg F	2.2×10^{-6}
Specific heat at 20 deg C	6.25 cal/gm atom/deg C
Thermal conductivity at 20 deg C	0.399 cal/cm^2/cm/deg C/sec
Electric conductivity	31 per cent IACS
Electric resistivity at 0 degrees C	5.48 uohm-cm
Temperature coefficient of electric resistivity per deg C (20-100 deg C)	0.00482
Apparent positive ion work function	4.55 ev
Apparant positive ion emission	11.93 ev
First ionization potential	7.60 ev
Magnetic Susceptibility	$+40\times10^{-6}$ gm atom
Tensile Strength	
At room temperature	100,-500,000 psi
At 500 deg C	175,-200,000 psi
At 1000 deg C	50,-75,000 psi
Young's modulus of elasticity	
At room temperature	59×10^6 psi
At 500 deg C	55×10^6 psi
At 1000 deg C	50×10^6 psi
Modulus of tortion	1.45×10^6 kg/cm^2

Thorium oxide, Thielemann notes, comes close—but at the required density it is too fragile. Tungsten could do the job, tests with small nozzles show. Now the question is, How do you make large tungsten nozzles?, Thielemann points out.

For unfortunately one of the major problems of tungsten is that the metal is hard, though not impossible, to work. As R. W. Yancey, consulting metallurgist on tungsten fabrication for Fansteel Metallurgical of North Chicago, Ill., told SPACE/AERONAUTICS, to work tungsten, you must heat it to temperatures at which stainless steel and some of the super-alloys would melt. After working, tungsten must be heated to about 2500 deg F for recrystallization.

The transition temperature of recrystallized tungsten is 600-750 deg F—as against the below-room-temperature value of most metals. Therefore, as Fansteel vice president H. W. Highriter points out, tungsten isn't ductile at room temperature, except in the very fibrous state, achieved only by very careful control of the fabrication process.

more on next page

Brazing Metals for Molybdenum and Tungsten

	Liquidus Temperature (deg F)
Ag	1760
Cu	1980
Ni	2650
Pd	2860
Pt	3225
Ag-Cu-Zn-Cd	1145-1295
Ag-Cu-Zn	1325-1450
Ag-Cu	1435
Ag-Mn	1780
Ni-Cr-B	1950
Ni-Cr-Fe-Si-C	1950
Ni-Cr-Mo-Si	2100
Ni-Ti	2350
Ni-Cr-Mo-Fe-W	2380
Ni-Cu	2460
Ni-Cr-Fe	2600
Pd-Ni	2200
Pd-Fe	2400
Pd-Ag	2400
Co-Cr-Si-Ni	2550
Co-Cr-W-Ni	2600
Mo-Ru	3450
Mo-B	3450
Cu-Mn	1600
Nb-Ni	2175

As a result, tungsten parts until recently, were made by powder metallurgy methods. These sharply restricted the part sizes that could be made. In addition, machining has been about the only way in which the compacts could be worked. Recently, however, there have been significant breakthroughs that promise much more latitude for tungsten parts. One of these is the development of plasma deposition methods (see *"Plasma Are Process Coats and Forms Refractory Materials," p. 105*).

Equally important are major advances in methods for working the metal and its alloys. Forgings can now be made by compacting the metal powder to a preformed shape. The compact is then sintered and forged to shape by steps that takes advantage of the material's increased ductility as it's subjected to further working.

Another new process is the production of seamless tungsten tube by hot-extruding. One part made by Fansteel was reduced by 70 per cent of its original area.

In addition, Fansteel recently reported new methods for deep-drawing and spinning tungsten parts. At first, blanks of 2½-3 in. diameter were drawn, but work has now advanced to where cups of up to six inches diameter can be drawn. Further size increases are expected.

Spinning has been used to make tungsten parts from sheet as thick as 0.17 in. With present equipment, engineers state, sheets up to 15x24 in. could be made. Indications are that, with improved techniques (involving, for example, larger rolling mills and new sintering equipment), this sheet size could be doubled. Spun shapes of up to 3½ in. diameter have also been made.

Deep drawing, it's noted, can be used to produce vector control surfaces for advanced vehicles. Deep-drawn tungsten boats also make it possible to fire electron tube components to higher temperatures.

Inertial guidance accuracy is improved

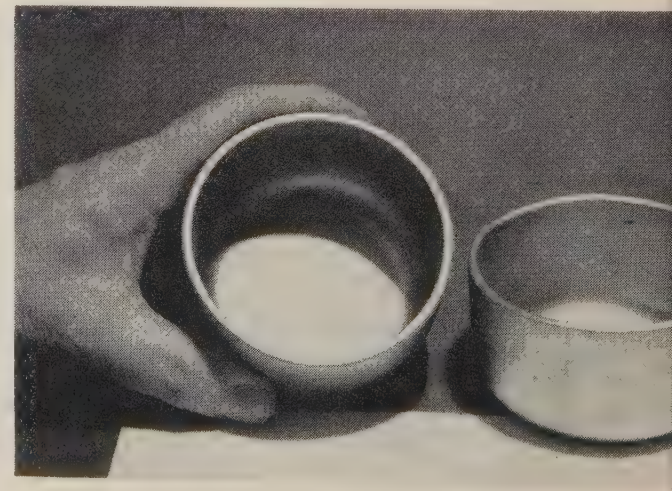
Deep drawing also provides rotor parts of pure tungsten, with a 20 per cent increase in density over the tungsten alloys that are used now. As Yancey states, pure-tungsten parts can provide an expansion coefficient of 3 instead of 8, allowing closer design tolerances and so greater accuracy. Conceivably, he told SPACE/AERONAUTICS, they could cut guidance errors from, say, 10,000 miles for space vehicles to only 500-1000 miles.

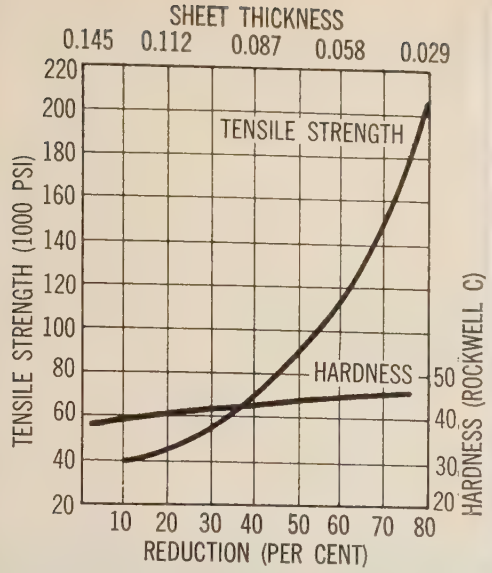
Metallurgists emphasize that a good understanding of the metal's limits and of the compromises it requires are vital to proper design use. For instance, Yancey believes that some of the failures with such materials as molybdenum haven't been due to the metal as much as to improper application. Because of its high density, he notes, tungsten should be used as sparingly as possible in such items as nozzles.

It might be possible, for instance, to use a relatively small tungsten insert in the extreme-temperature region and attach it with tantalum rivets to tantalum sections, taking advantage of the latter metal's excellent high temperature properties. Another method, it's noted, is to use a thin tungsten liner surrounded by a refractory outer section (made of Astrolite, for example). The refractory could be held in place by a retaining ring.

However, it's emphasized that designers should con-

TUNGSTEN CUPS drawn by new methods at Fansteel Metallurgical have 0.1-in. wall and are two inches deep. Cups of up to six inches have been drawn, and further size increases are expected.





EFFECT of reduction by rolling (left) on the tensile strength and hardness of tungsten sheet. Right: Tungsten parts must be hot-worked at very high temperatures, as in this fabrication operation at Fansteel.

sult with tungsten suppliers in such cases because of possible metallurgical changes in the combinations. For instance, graphite as a backup might look good at first glance. But it could react with tungsten to form tungsten carbide, a material with a lower melting point than tungsten, Yancey points out.

Basic hardness must be considered

The basic hardness of pure tungsten (40RCI) must also be kept in mind. Otherwise it may, for instance, be very difficult to obtain the desired finished part. An example would be the design of a drawn-tungsten jetavator requiring a squared cup. The rough part could be made, but at the present state of the art the excess material at the cup edges probably could be removed only by hot shearing. Current practice is to rough-machine a tungsten part and then finish-grind.

At present, metallurgists suggest, it's best to leave the production of tungsten parts to the supplier. A key reason is the metal's transition temperature. Tungsten can be riveted, for example, but only over the transition temperature.

In addition, a lot of skill is needed in designing tools and dies, since tungsten has high thermal conductivity and low specific heat, while tools have just the opposite properties. So the tool tends to expand and work against the contracting forces of the tungsten. Unless the operation is performed extremely swiftly, a cracked part will result.

All tungsten work must be done hot, and the alloy can't be cold-sheared. Fansteel heats tungsten in an electric furnace with a hydrogen or cracked-ammonia atmosphere. Gas flames can't be used, because of tungsten's poor oxidation resistance (which makes the development of oxidation coatings another key problem).

With proper working at the right temperatures, Fansteel reports, 3/8-in. holes can easily be punched in 3/16-in. sheet. Half-inch holes have also been punched in 3/4-in.-diameter, 0.005-in.-thick washers for electronic gear.

Tungsten has been successfully filler- and Heliarc-welded, but Fansteel researchers still state that welding isn't advisable. The weld itself is good, but the heat zone around carries the metal beyond the recrystallizing temperature and causes brittleness. This condition can't be corrected, since the fabricated part can't be reworked, it is pointed out.

For forgings, it isn't possible to give a general rule on reductions. For instance, the characteristics of a two-inch part differ from those of a one-inch part, because of the difference in the amount of work that has been done, to which tungsten is very sensitive. There would be differences in grain size, grain configuration, etc.

A safe design radius for tungsten is four times the sheet thickness (at temperatures determined by the amount of previous working). It's also important to consider the question of stress relieving. Even though tungsten is worked hot, the metal must be worked in the 22-2400-deg F range when stress relief is needed.

Tungsten alloys are also being studied. The addition of one per cent nickel greatly increases tungsten's machinability, but also decreases the melting point. Thielemann reports that a chrome system with a little tantalum and at least 90 per cent tungsten looks promising. This alloy has good oxidation resistance but is brittle. An alloy of 60 per cent tungsten and 40 per cent rhenium, he states, has many excellent properties.

Tungsten wire also offers interesting design possibilities. For instance, a wire drawn to a diameter of 1/1000 in. would have a tensile strength of 600,-700,000 psi. Tungsten wire might possibly be wrapped around a mandrel to form a rocket case, Thielemann suggests.

Tungsten has short time tensile strengths of 31,800 psi at 2200 deg F, 10,700 psi at 2732 deg F, and 3400 psi at 4082 deg F (recrystallized before testing at these temperatures).—End

Ten-man space station

for assembly in orbit

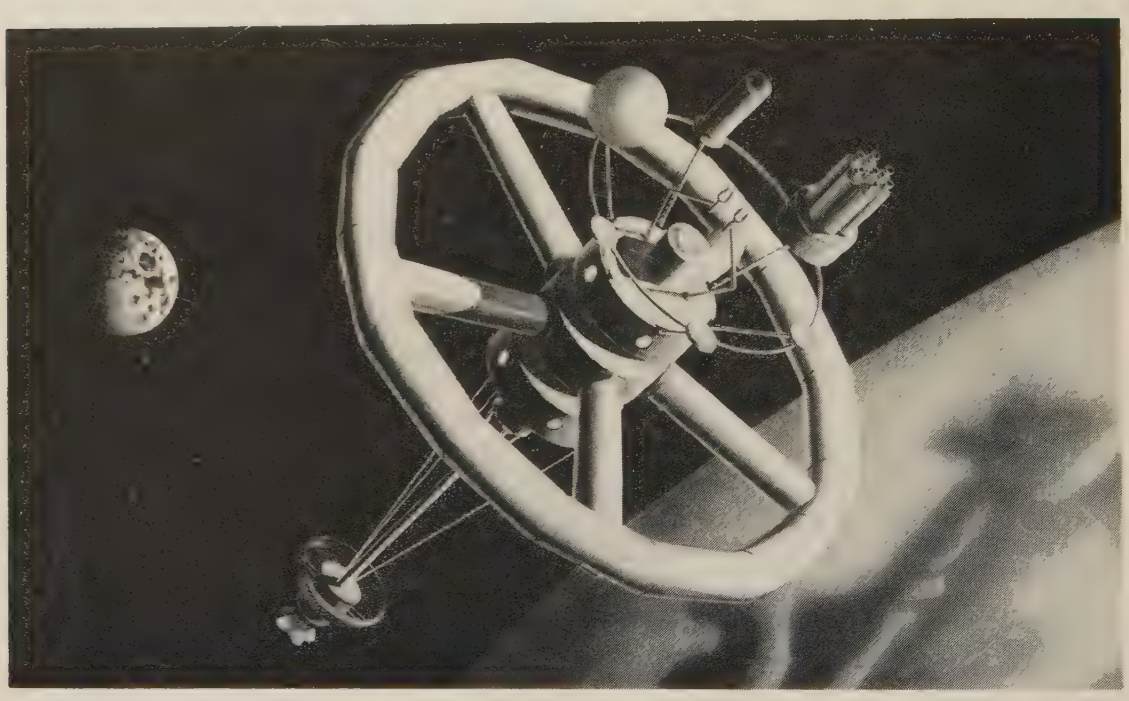


FIGURE 1: Space station to support a scientific staff of ten men in complete independence for six months would weigh about 475 tons fully equipped and provisioned.

This is the second article in a series offering a detailed analysis of the requirements of a multi-manned satellite based on the current state of the art. Last month's article (p. 52) covered the booster design; the concluding article next month will take up the station's "auxiliary" vehicles.

by S. B. Kramer and R. A. Byers,

Space Vehicle Design Scientist & Staff Engineer, resp., Missile & Space Div., Lockheed Aircraft Corp.*

A 10-MAN scientific space station could be put into a 500-mile high orbit by 1970. This date is optimistic but realistic. It assumes preliminary design is started by 1960. Final design will put to good use the experience from the Mercury and Dyna-Soar projects and with one- and two-man minimum space stations.

Basic design concepts have already been worked out in considerable detail. Each section of the space station will be prefabricated on the ground as a sealed compartment about 20 ft long and 10 ft in diameter. Provisioned to support several men for a number of months, the compartments will be separately launched

* Missiles & Space Div., Lockheed Aircraft Corp., Sunnyvale, Calif. This is a condensation of a paper, "Proposal for the Assembly of a Multi-Manned Satellite," given at the national meeting of the American Astronautical Society in Washington, D. C., last December 27-30.

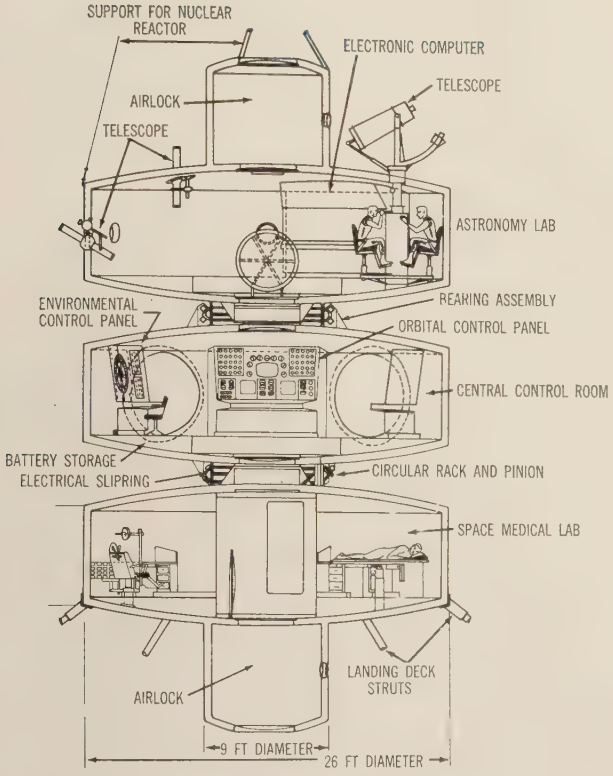


FIGURE 2: Detail design of the space station hub.

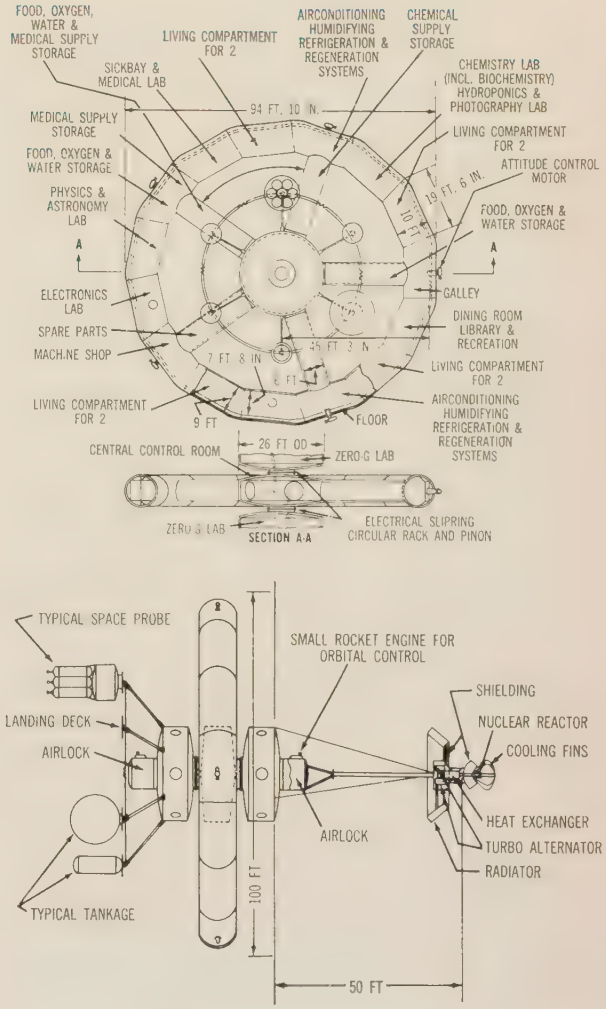


FIGURE 3: Plan view and elevation of 10-man space station. The outer hub compartments remain stationary, providing a zero-G environment, while the central hub compartment and the outer rim rotate about the station's longitudinal axis. The attitude control rockets on the outer rim rotate through 360 deg and can be fired collectively or separately.

into approximate orbit, rounded up by ground control and manned space "tugs" into a precise orbit, and finally coupled together to form the station (*Fig. 1*).

The first compartment placed in orbit serves as a control center for space operations. It is equipped with a transponder to identify itself as the homing target, a satellite control reference platform to establish a coordinate reference for orienting the other compartments, ranging radar for determining the spacing of the compartments on orbit, and a computer-memory unit for keeping the correct distances between compartments.

Each compartment is put into orbit by a launch vehicle whose third-stage guidance and control system brings the compartment payload into orbit at 500 miles altitude in the general vicinity of the compartments already placed in orbit. However, the programed guidance cannot provide the fine control adjustments needed to "bunch" the compartments. Each compartment needs its own rendezvous attitude control system. Relatively crude, this system consists of an inexpensive two-axis erecting gyro, a small transistorized computing unit, a nitrogen jet system, and a set of flow control valves.

Upon separation from the launch vehicle, the attitude system stabilizes the compartment in orbit. The longitudinal axis is made to parallel the local vertical and the transverse axis of greater moment of inertia to parallel the orbital velocity vector. Erecting the gyro

more on next page

Space Station Weight and Power Analysis

	Weight (lb)	Avg. Power (W)	Peak Power (W)
5 Living quarters (incl. crew total)	100,000	4475	14,040
2 Environment regeneration units (total)	40,000	10,210	22,350
5 Storage spokes for (total)	100,000	1730	9040
Lower hub & astronomical lab	20,000	7637	25,214
Central hub & control station	20,000	9590	28,328
Upper hub, power station & Zero-G Lab	20,000	4615	13,553
Physics & radiation lab	20,000	3899	15,958
Chemistry lab, photography & hydroponics	20,000	2989	5828
Bio-medical Lab & sickbay	20,000	2496	9283
Machine shop & instrument Lab	20,000	4830	24,000
Electronics lab & repair unit	20,000	5739	28,308
Storage unit for food & supplies	20,000	584	2324
Recreation hall & ward room	20,000	1880	5008
Galley & utility room	20,000	6434	54,458
Nuclear reactor & control equipment	5,000	2000	5000
Shielding for nuclear reactor	14,000		
Tower structure for reactor	1,000		
External tankage (tethered, full)	100,000		
4 Re-entry vehicles (tethered, total)	80,000	4000	14,000
4 Tug vehicles (tethered, total)	80,000	4000	14,000
10 Lunar probe vehicles (total)	200,000	10,000	10,000
Miscellaneous	10,000	1000	3000
Total	950,000	86108	303962

to the stabilized longitudinal axis takes care of the high drift rate inherent in a cheap gyro, so that there is no accumulated gross error in attitude.

While on separate space orbits, the compartments are tracked and guided in orbit from the ground. (Each compartment has its own coded VHF tracking beacon for identification and easier tracking.) Radio command signals from the pilot compartment are used to control the operation of vernier jets for maneuvering in space and to bring the compartments into a cluster spread out over a few miles. For final assembly, a small manned space tug "captures" and aligns the compartments for automatic coupling.

Peripheral acceleration of one G

Once the assembly is completed, all of the space station except for the outer hub section's are spun up by tangential jets to produce a one-G acceleration in the rim periphery (*Fig 3*). The upper and lower hubs are held stationary in inertial space by servo drive-motors acting against the spin of the central hub. An attitude control unit for the entire station holds the spin axis perpendicular to the local vertical and to the orbital velocity vector to eliminate percession.

The initial space station orbit is established during assembly to coincide approximately with a predetermined standard orbit that remains fixed for the life of the station. Orbital control consists of corrections to the actual orbit as it drifts from the standard orbit.

The perturbations that might affect the orbit are small radiation pressure, atmospheric drag, impulses from gas leakage from the space station or imparted by supply-vehicle momentum, etc., are all easily corrected. The oblateness of the earth and the gravitational attractions of the moon and sun need not be corrected for since their effects determine the standard orbit.

Microthrust orbital corrections are supplied by two rocket motors installed near the outermost ends of the space station hub (*Fig. 2*). Since the direction of thrust is determined by the attitude of the outer hubs, all scientific observations for attitudes different from those required for orbital control must temporarily be suspended. But orbital control is performed so infrequently that the delay is insignificant.

The space station configuration approaches the form of a toroid quite closely. The peripheral ring, made up of 15 compartments, is connected to a central hub by five spokes that provide storage areas for food, oxygen, water, and other supplies. The hub is made up of three similar cylindrical compartments (*Fig. 2*).

The hub's central control room is about nine feet

high at the center and six feet at the edge. It contains the control equipment for the entire satellite, including power, propulsion, communication, telemetry, and all other major system controls, as well as the air conditioning, humidifying, refrigeration, and regeneration systems for the entire hub.

Structurally each of the outer hubs consists of two primary cylinders placed concentrically and reinforced by equally spaced ring angles. Both outer cylinders are pressurized. The inner capsule, which contains the life-sustaining environment, is sealed fore and aft by pressure bulkheads and self-sealing doors.

Floor and ceiling carry the loads

The basic load-carrying members within the inner capsule are the floor and ceiling. Both are supported by web members that carry the load through the pressure vessel into the ring angle members.

A docking facility at one end of the hub is used for landing and tethering vehicles, tugs, tankage, and unattached equipment. It consists of a semi-flexible structure made up of six radial booms and a circular segmented rim attached to the lower hub compartment. Each boom is coupled to the hub by a stiff coil spring. The rim segments are coupled together and to the tips of the booms by similar springs, so that the entire structure is free to deflect under collision loads without damage.

Vehicles approaching the station may aim at any unoccupied segment of the rim and safely collide at a differential velocity of about 10 fps. Upon contact, a special attachment fitting closes around the rim so that the energy is absorbed without structural damage. A vehicle may approach at almost any angle not screened by the structure of the station itself.

Manipulators on the lower hub of the station grip landing vehicles to move them into register for coupling to the airlock. After passengers and cargo have been transferred through the airlock into the station, the vehicle is closed, moved out again, and attached to the rim of the boom structure. An umbilical connection supplies gas, fuel, and electric power to the vehicle during standby, and an automatic monitoring circuit continually checks for operational readiness.

The space station is equipped with a variety of redundant communciations devices so that a constant communications linkage can be maintained under all conditions. Each compartment also contains an emergency radio and power batteries.

Both HF and VHF radio are used for normal communications. The system contains two transceiver units, one for voice modulation and the other for pulsed CW. With a pulse power ratio of 1000, a transmitter with 100-W average power will produce a peak pulse power of 100 kw. As an emergency backup, there is an infrared optical communication system. It has a 12 in.-diameter transmitting reflector telescope with a 24 in. focal length and a receiver telescope of the same size. Beacons can also be used for communication.

Electric transducers are used to measure physical phenomena vital to the operation of the station. The readings are displayed to the crew on visual instruments and gages and are also continually telemetered back to earth.

Signals from each transducer are fed into a time-sharing multiplexer, so that many signals may be recorded on a single channel. The recording tape is impressed at real-time speed and then played back at a greatly increased speed for transmission to ground stations.

A nuclear generating system supplies the station with electric power. It can supply an average load of 86 kw, with a peak of around 275 kw. A fast breeder-type reactor is used, with a heterogeneous core cooled by liquid metallic sodium. Shadow shields of lithium hydride and uranium protect the crew and station structure.

The major elements of the system are:

- a one-megawatt reactor as a prime energy source, equipped with a pump for circulating sodium coolant,
- a counter-flow heat exchanger of 6000 btu/sec capacity,
- two multi-stage reaction turbines driving 400-cps, 208-V, three-phase alternators rated at 200 kva each for lighting, motors servo systems, and lab equipment,
- a radiator capable of dissipating 5600 btu/sec,
- a synchronous converter for changing 400-cps, three-phase ac into dc,
- a 3200-cps, 115-V, single-phase transistor-oscillator static inverter to supply high frequency power for the electronic gear,
- negative and positive 28-V dc power supplies for transistorized units and miscellaneous equipment,
- a battery pack of 500 amp-hr capacity for emergency standby power.

The two turbo-alternators are designed to operate on a Rankine closed cycle, using a common supply of mercury vapor as the working fluid. Valves automatically isolate either turbo-alternator in case of a failure.

The complete assembly of reactor, gamma and neutron shadow shields, heat exchanger, turbo-alternators, and condenser is mounted on the end of a tubular structure about 50 ft long. All transformers, converters, circuit breakers, and associated equipment are located in the central compartment of the hub, which also contains the main distribution panel.

Solar power could also be used

A solar power unit might be used in place of the reactor. It consists of 100 tiltable reflectors, a liquid-metal-type boiler, and a turbine drive. The turbine rotates a conventional generator at high speeds to produce 400-cps ac, 3200-cps, and dc power. The dc is used to charge the batteries, so that power is available even when the space station is in the shadow of the earth.

Liquid-metal-cycle-type design is best suited to high-temperature operation. The boiler itself consists of a cylindrical structure that in use is mounted on the upper hub, extending out along the axis of the station. Surrounding and perpendicular to it is a radiation plate about 40 ft in diameter on the end of the upper station hub. A liquid-metal pump moves mercury from the condenser to the boiler for vaporization and use in the turbine.

Each reflector is a curved plate made of high reflective metal. Mounted on the outer rim of the space station, the reflectors are pivoted at the C.G. Each is turned by a synchronous electric motor and linkage to catch the sunlight and direct it onto the boiler. Once synchronized, the entire system of reflectors moves in unison as the station rotates.

A solar tracker keeps all the units in proper phase relationship. The entire weight of the system, including reflectors, structure, drive motors, boiler turbine, generator, and condenser, should be under 8000 lb.—End

COUNT DOWN

for the conquest of space

"MISSION ACCOMPLISHED: DEPARTING LUNA 2205 ZEBRA"

This message, flashed across a quarter-million miles to Washington, D.C., will be awaited anxiously by millions.

But even then our first expedition to the moon will still face its most crucial test—the journey home to earth.

The success of that trip will depend in large part on rocket propellants—fuels and oxidizers that will have been stored for days in the tanks of the expeditionary vehicle and yet will respond instantly when needed.

Storable liquid propellants is one of the fields in which Rocketdyne has anticipated the future. For more than ten years, its propellant chemists have been studying, engineering, and testing combinations of storable fuels and oxidizers for greater storability and higher energy.

Storability PLUS high energy

Rocketdyne has tested these combinations in all production and experimental engines. The results prove that today's storable fuels and oxidizers have these important capabilities:

(1) High performance, even after months or years of storage; (2) Stability over a wide temperature range, permitting storage in missile tanks without rigid environmental controls; (3) Dependable performance, predictable even at extremes of heat and cold; (4) Instant readiness for firing at any time during the storage period; (5) Energy yields equal to or higher than those of conventional propellant combinations.

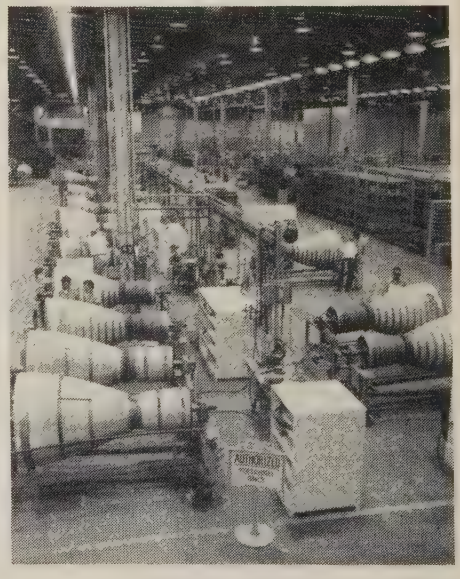
Second-generation missiles

The tests also prove that engines developed for conventional propellants can be converted to storable combinations rapidly and inexpensively—a significant consideration in the development of second and third generation strategic, tactical, and air defense missiles.

Significant, too, is the *potential* performance of storable combinations. Research points to energy yields as high as 400 seconds of altitude specific impulse—performance 20 percent higher than that of today's combinations. These high-energy yields will offer new capabilities and greater flexibility for America's scientific and military programs.

Stepping stones to Space

Rocketdyne has designed and built much of today's operating hardware in the high-thrust rocket field. Engines by Rocketdyne power most of the military and scientific projects sponsored by Air Force, Army, and NASA. This experience now becomes the point-of-departure for tomorrow's journeys into the unknown.



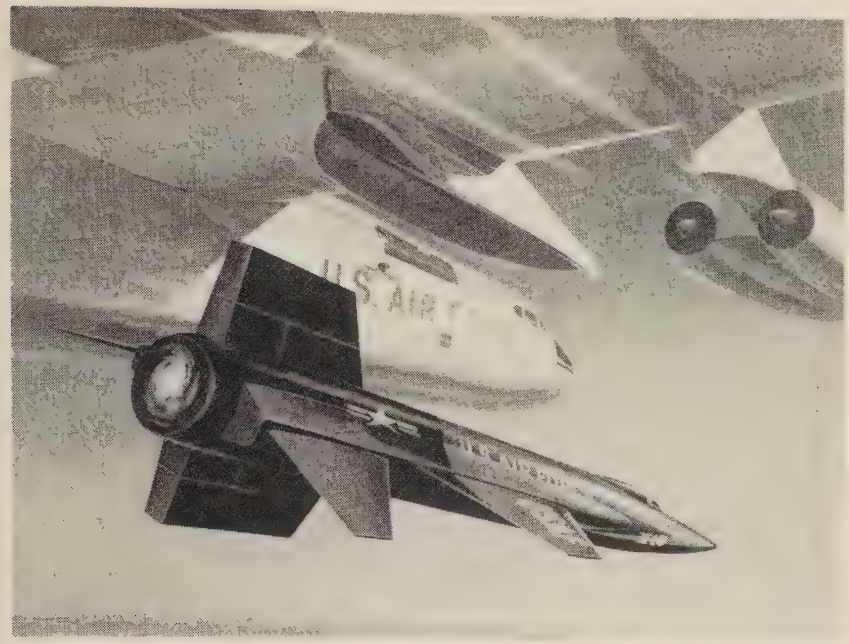
POWER FOR AMERICA'S MISSILES

Thrust chamber production line for Thor and Jupiter at Rocketdyne's Neosho, Mo., facility moves smoothly.

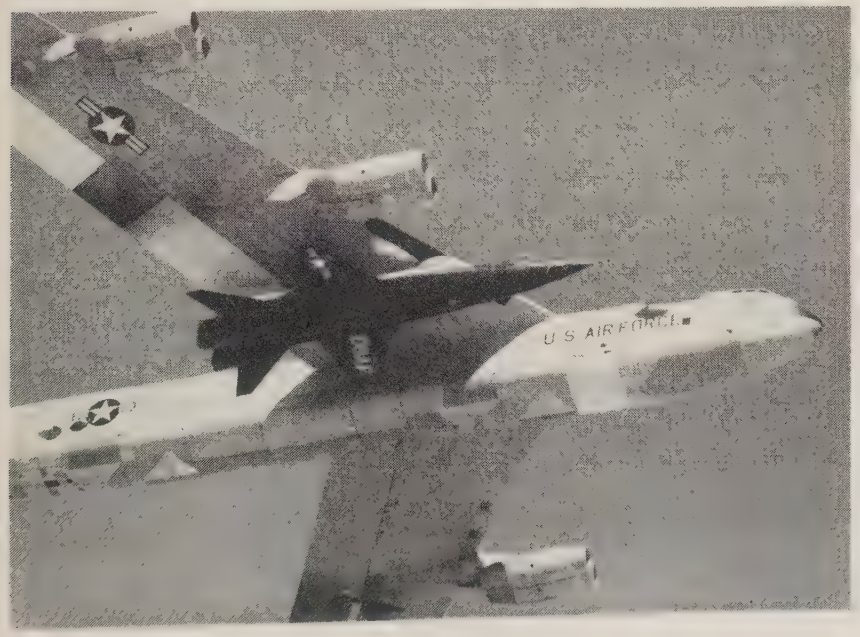
FIRST WITH POWER FOR OUTER SPACE

ROCKETDYNE

A DIVISION OF NORTH AMERICAN AVIATION, INC.



X-15 WILL BE LAUNCHED from under the wing of a Boeing B-52 bomber at a probable altitude of 30,-40,000 ft. It will then climb to its maximum altitude of 400,-800,000 ft. In current captive flight tests (below), all equipment except for the main rocket engine is tested to simulate actual flight.



design progress

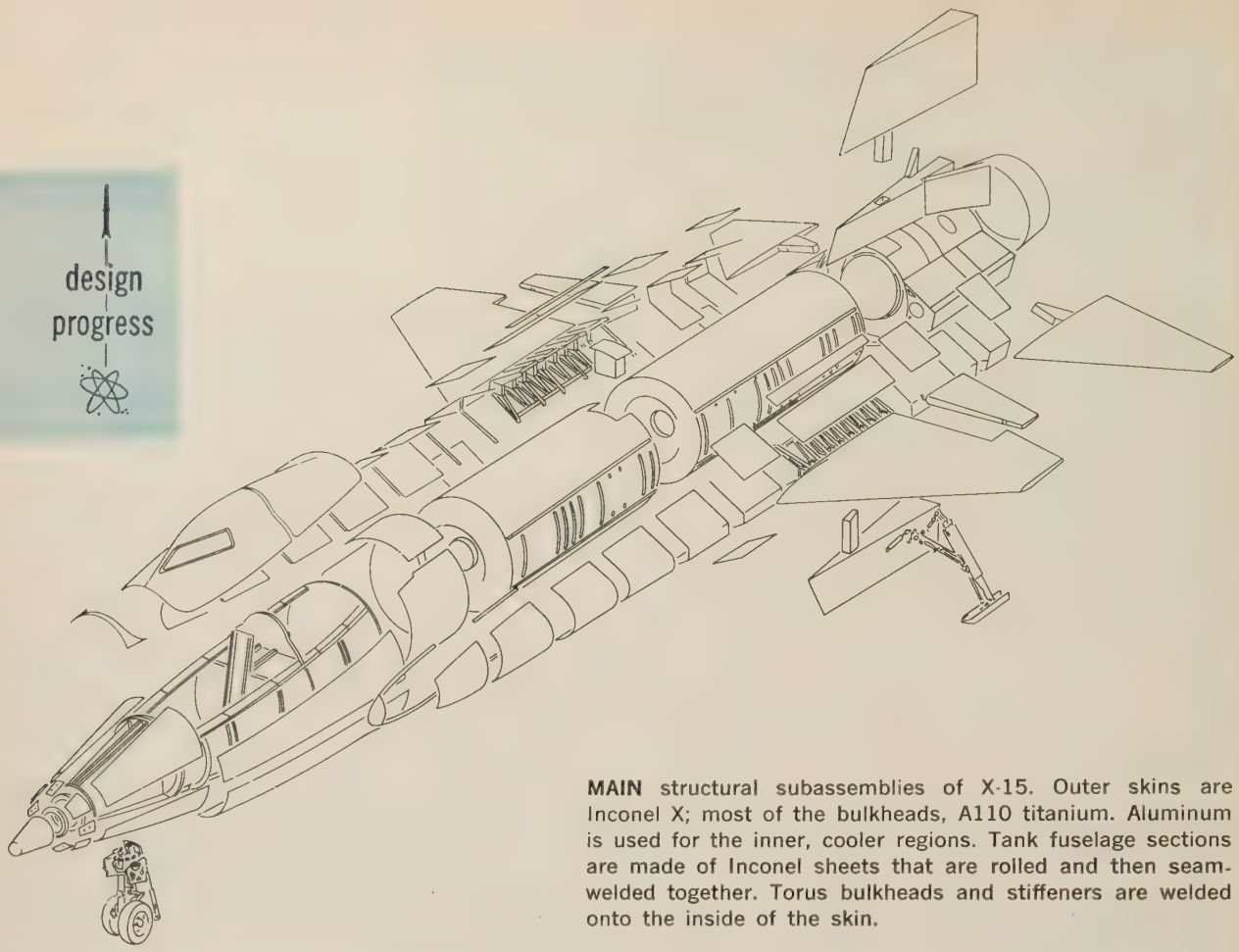
by Irwin Stambler
Associate Editor

Simple mechanical linkage controls X-15's reaction jets

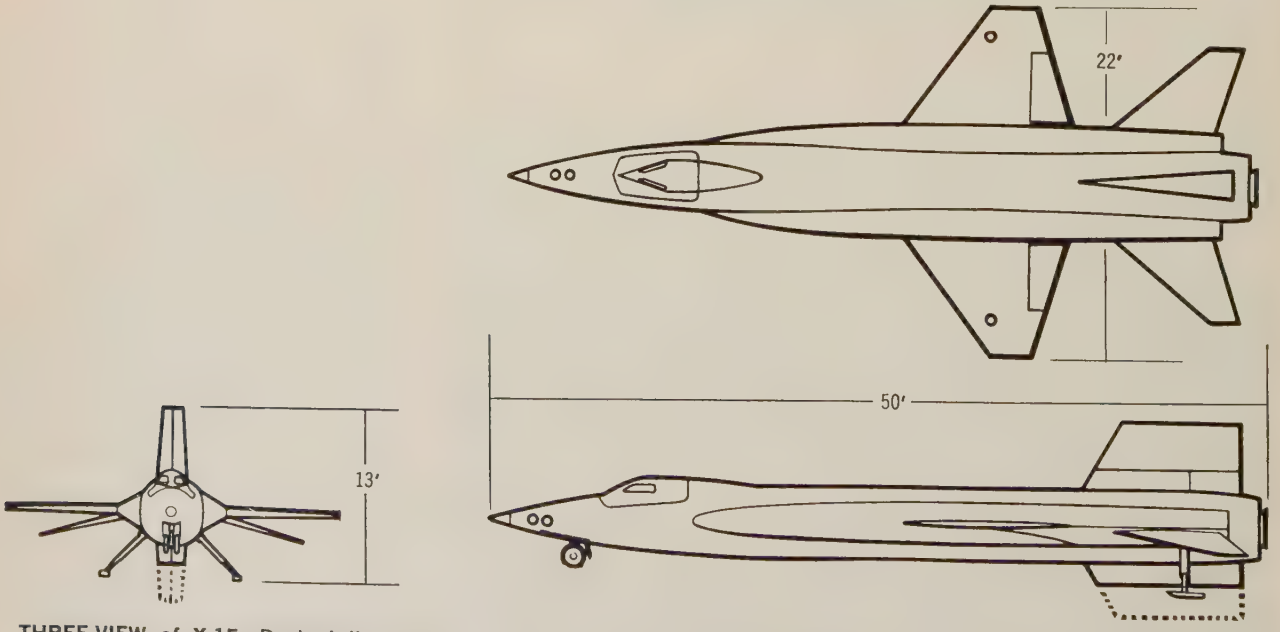
DESIGNED by North American Aviation for the joint Air Force-NASA-Navy space program, the X-15 will soon begin its free flights. When it makes its all-out run, it will reach speeds of 4000 mph and altitudes of 800,000 ft. The basic engine of the craft will be Reaction Motors' XLR-99, providing over 50,000 lb thrust. For the first flight tests, two RMI-XLR-11 interim engines (the type used on the X-1) will be installed. Propellants are liquid ammonia and liquid oxygen fed by a pressure system providing a flow of over 10,000 ppm. Tail control surfaces, speed brakes, and landing flaps are powered by two separate 3000-psi systems operating in parallel. The air conditioning and pressurization system weighs 150 lb and has a cooling capacity of 27,000 btu. The craft will have 90 seconds of powered flight time at a total flight time 20 minutes. Wing area is 200 sq ft; sweep at quarter chord, 25 deg; and weight at launching, 31,275 lb.

more on next page

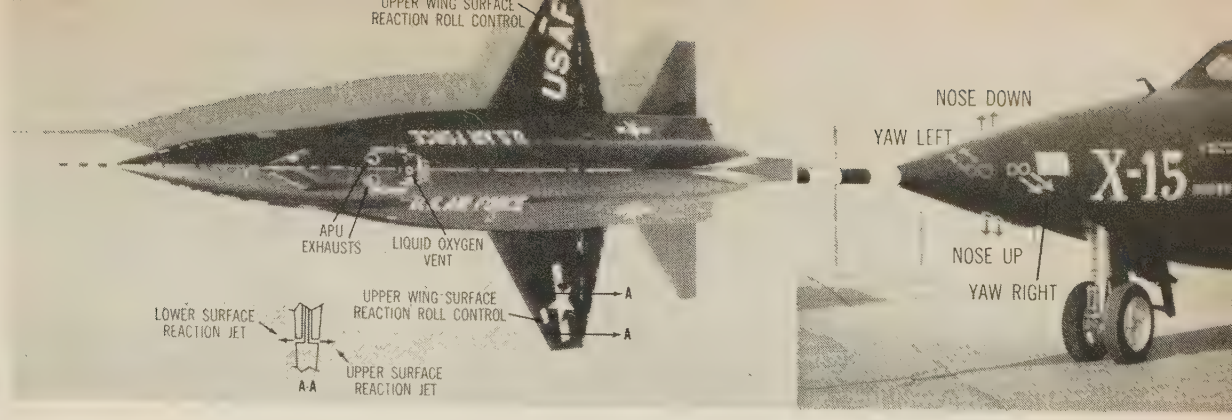
design progress

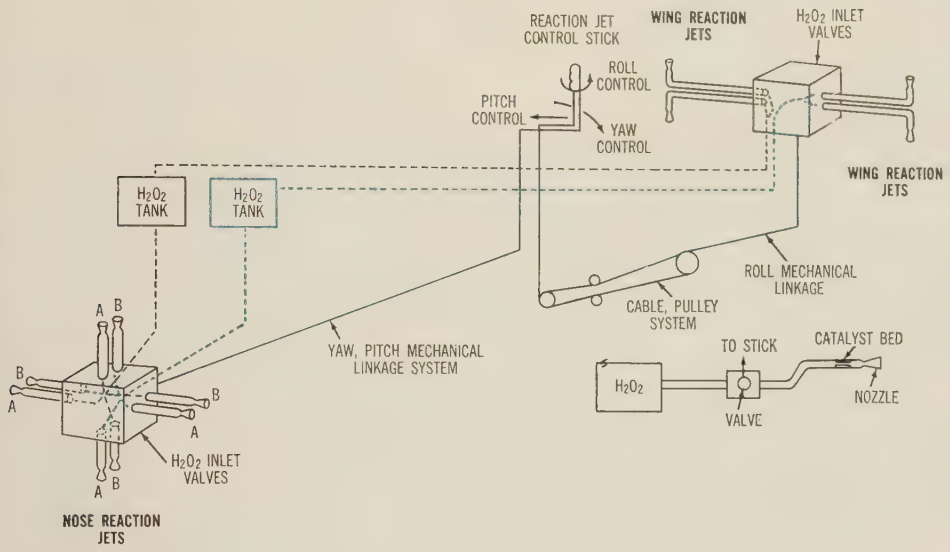


MAIN structural subassemblies of X-15. Outer skins are Inconel X; most of the bulkheads, A110 titanium. Aluminum is used for the inner, cooler regions. Tank fuselage sections are made of Inconel sheets that are rolled and then seam-welded together. Torus bulkheads and stiffeners are welded onto the inside of the skin.

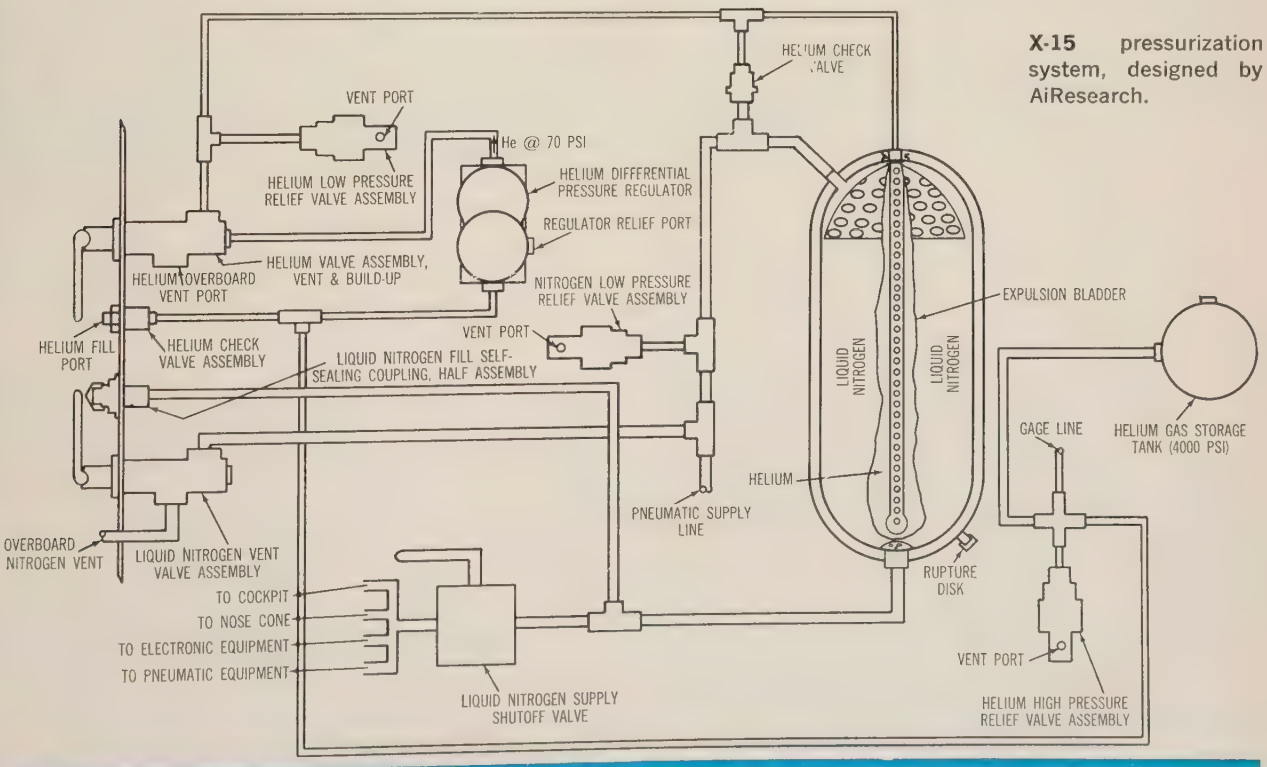


THREE-VIEW of **X-15.** Dashed lines show vertical tail section, jettisoned before landing.





X-15 REACTION JETS are used for attitude control after burnout of the main engine. They are arranged in dual systems for fail-safety—in the nose, for example, the four "A" jets receive H_2O_2 from one tank and the four "B" jets from another, entirely separate one. Each system reportedly can provide about 113 lb for thrust pitch and yaw and 40 lb thrust for roll. The pressurized H_2O_2 used by the jets is activated across a catalyst bed designed by Bell Aircraft (left), expanded into steam, and ducted through a nozzle to produce thrust. The reaction control stick is completely separate from the aerodynamic control stick. It actuates proportional valves that control the flow across the catalyst bed.



X-15 pressurization system, designed by AiResearch.

In the event of attack...we cannot expect more than minutes warning and minutes to retaliate. Heretofore ...inertial systems in air-launched missiles required as much as thirty minutes warm up time before operation and an additional amount of time before achieving specified accuracy. The new G.E. Platform is designed specifically to give satisfactory performance over a wide range of temperatures in high G environments.

It is smaller in size and weight than similar platforms and the following features are indicative of the performance to be expected:

1. Fully operable within one minute after power is applied.
2. 20 minutes after –55°C start–it achieves accuracy as specified.
3. Ambient temperature –65°C to + 100°C.
4. Tolerates high acceleration environment.
5. Platform and associated electronics total only 55.7 pounds.

This lightweight ruggedized environmental suited platform is ideal for long range air launch missiles. The unusually low drift rate eliminates necessity of "trimming" or adjusting the gyro bef each mission.

More complete details are available on the s tem by contacting Manager–Control Sales, Gene Electric Company, Light Military Electronics D partment, Armament and Control Section, Johns City, N. Y., Dept. 12G.

Send for free illustrated brochure

LMED

GENERAL ELECTRIC

LIGHT MILITARY ELECTRONICS DEPARTMENT
FRENCH ROAD, UTICA, NEW YORK

A DEPARTMENT IN THE DEFENSE ELECTRONICS DIVISIO

Write in No. 20 on Reader Service Card at start of Product Preview Section

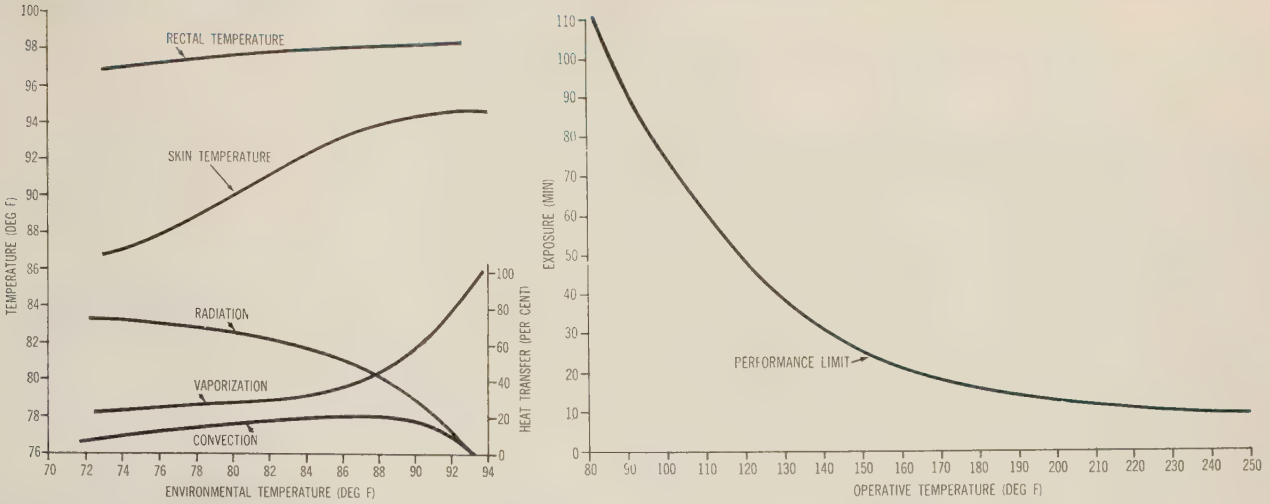


FIGURE 1: Radiation, convection, and vaporization as they affect heat balance of a man in a hot environment with relative humidity of 20-30 per cent and air movement by natural convection (left) when skin temperature has reached 95 deg F, essentially all of the body heat produced by cell metabolism (300-500 btu/hr in a resting adult male) is dissipated by vaporization. Because of this, rectal temperature rises only slightly even though radiant and convective cooling have approached zero. (Adapted from Hardy.) Right: For studies of human performance under heat loading, tolerance time is related to operative temperature.

Heat protection for space crews

Cabin design for space flight can only be as good as the human tolerance data on which it is based. Unfortunately, when it comes to heating conditions, many of these data in the literature are inadequate because they oversimplify the problem. Here is an analysis of the many factors that influence man's response to heat.

by Earl T. Carter, Assistant Professor, Dept. of Preventive Medicine, The Ohio State University*

HUMAN beings maintain a heat balance—and so a constant body temperature—through their unique ability to continuously adjust heat transfer coefficients and "constant" parameters. The heat balance therefore is difficult to calculate; however, its general principles can be set out quite straightforwardly.

Human heat balance exists when:

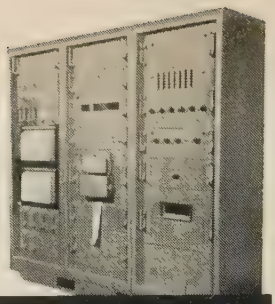
(1) $$Q_m + Q_o = O,$$

where Q_m is the "metabolic" heat produced by the body cells and Q_o the heat transfer between the body core and the enivornment. Q_o can be taken as negative for heat flow away from the core and as positive for in-

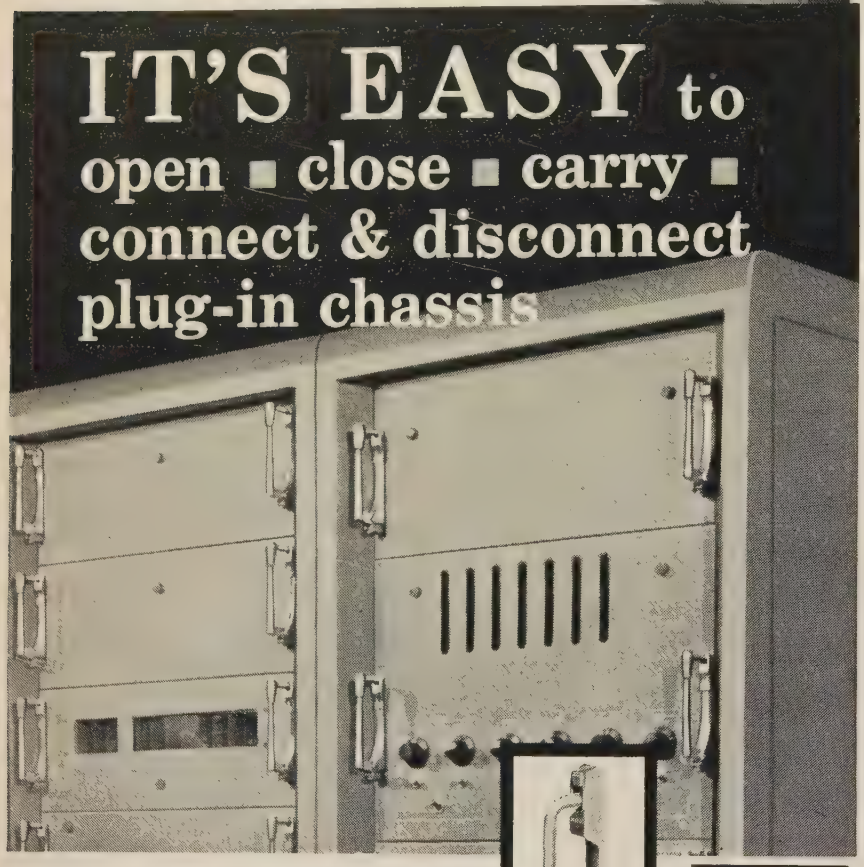
* Dept. of Preventive Medicine, The Ohio State University, Columbus 10, Ohio.

more on next page

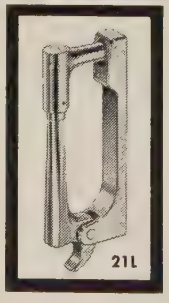
DATICO "digital automatic tape intelligence check out" is made by the Nortronics Div. of Northrop Corporation for the U. S. Air Force and U. S. Army Rocket & Guided Missile Agency. This money and man saving tool provides rapid weapon system evaluation. Note Camloc Chassis Latches.



IT'S EASY to open ■ close ■ carry ■ connect & disconnect plug-in chassis



with Camloc®



multi-function CHASSIS LATCHES

Thirty-eight strong, simple, attractive Camloc multi-function Chassis Latches are used on the 24 equipment filled plug-in chassis that make up DATICO, the military's new universal automatic field service checkout system. Here is a perfect example of designed-in fastener serviceability, flexibility, ease of handling and economy in interconnected "black-box" systems. When the Camloc push-button handles are released and pulled down, the chassis is automatically disconnected and ejected. Then the latch becomes a carrying handle. When replacing the equipment the latch firmly pulls the chassis back in place, making perfect, automatic reconnection of multiple-pin units. It is quick, safe, reliable, vibration-proof. Camloc Chassis Latches consist of only two parts—a handle and a fork—mounted with standard screws. Several handle and fork designs are currently available, all interchangeable. *Write for Camloc's new Bulletin 35L today.*

"Specialists in Fasteners for Industry"

CAMLOC FASTENER CORP. • 13 SPRING VALLEY RD., PARAMUS, N. J.
WEST COAST OFFICE: 5410 WILSHIRE BLVD., LOS ANGELES, CALIF. • SOUTH WEST OFFICE: 2509 W. BERRY ST., FORT WORTH, TEXAS

Write in No. 21 on Reader Service Card at start of Product Preview Section

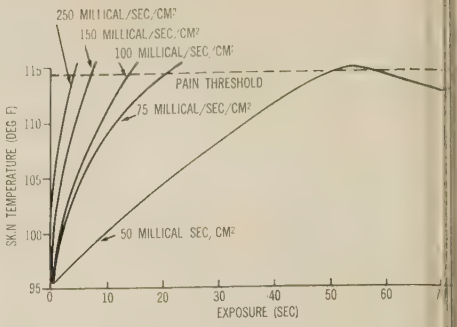


FIGURE 2: Skin temperature vs time for various levels of radiant heating.

ward flow. If $Q_m + Q_o$ is positive, the body temperature rises; if it is negative, the temperature falls.

Tissue transfer includes blood circulation

Q_o can be defined by:

$$(2) \quad Q_o = C_t(T_c - T_s) = C_a(T_s - T_s),$$

where T_c, T_s, and T_a are the temperatures of the body core (as estimated from rectal measurements), the skin surface (as a mean based on the body's entire surface), and the surrounding air; C_t is the thermal conductance through the body tissues (another mean); and C_a, the apparent conductance of the air mass exchanging heat with the skin. For a resting adult male, Q_o normally is around 50 kcal/hr per square meter of body surface.

The rather complex tissue transfer function $C_t(T_c - T_s)$ covers not only the passive heat conduction through the body's tissues but also the blood circulation. Blood is always flowing between the interior and the skin of the body and carries heat in accordance with its volume flow rate and specific heat.

Greater blood flow adds to work load

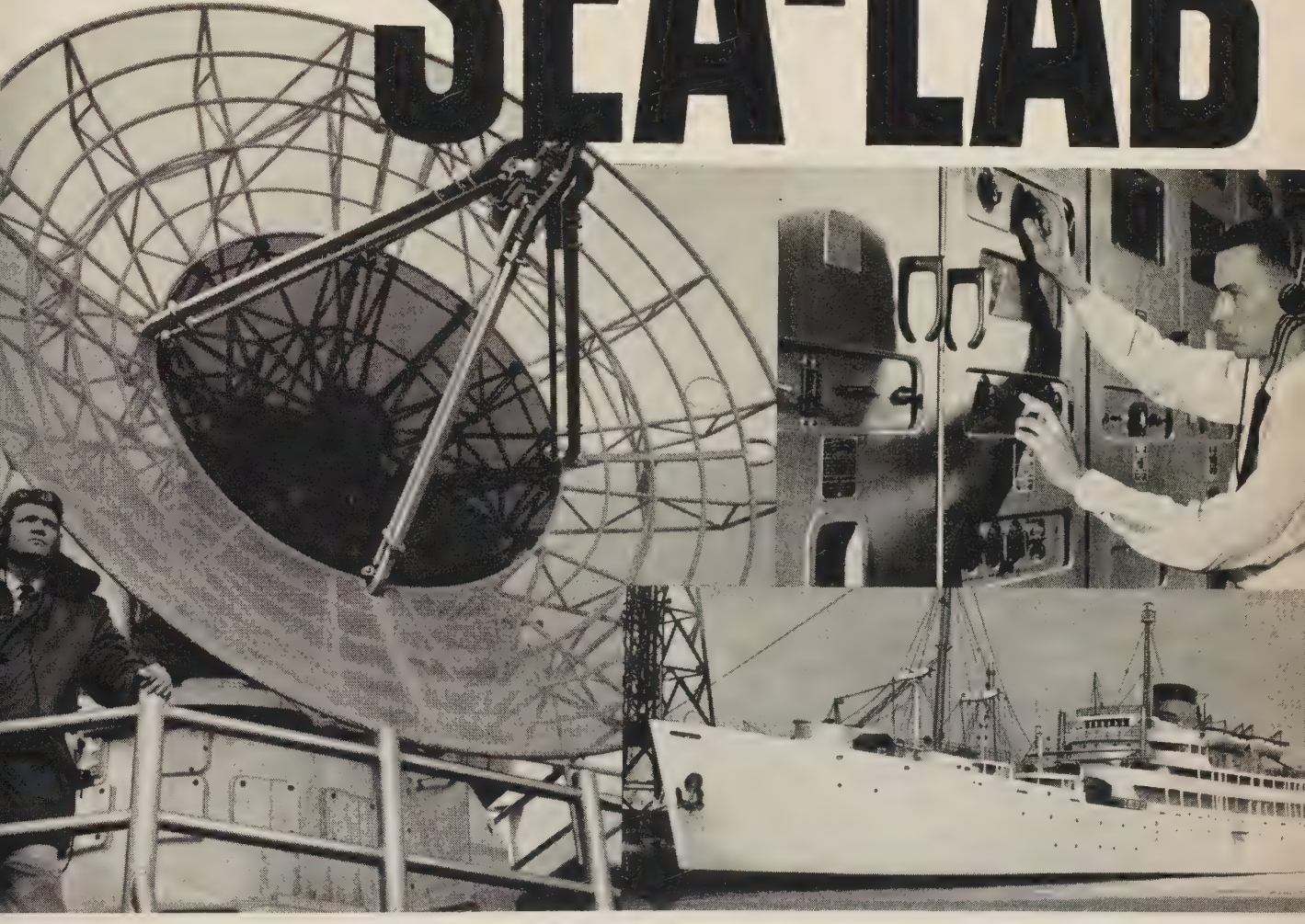
When $T_c - T_s$ decreases because of any heating of the skin, C_t is increased by greater blood flow through the skin. There is a drawback, though — any increase in the blood flow ultimately adds to the work load imposed on the heart.

Normally, $T_c - T_s$ is roughly eight degrees F (from 99 to 91 deg F). When it drops to 2-4 deg F, the body temperature rises, for even with maximum blood flow C_t

more on page 64

MISSILE TRACKING

SEA-LAB

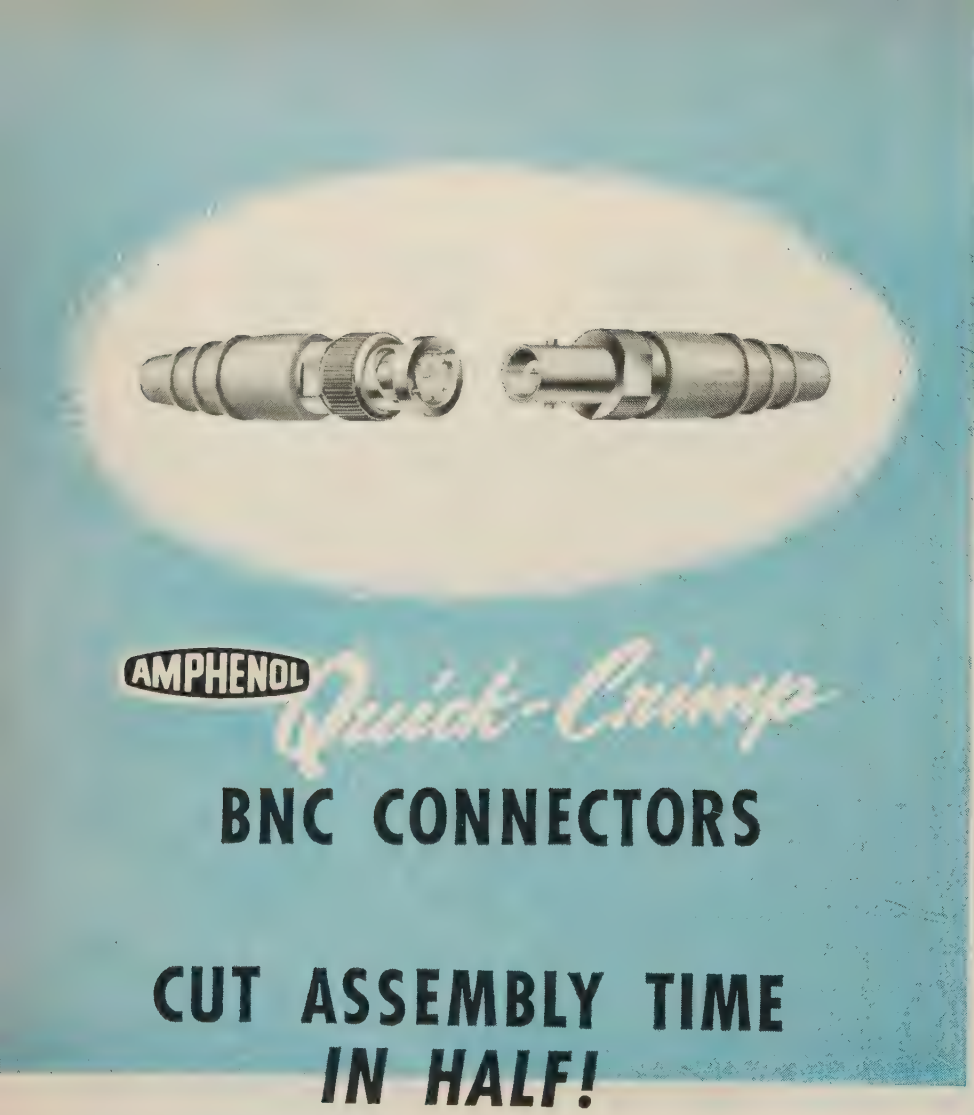


This huge antenna is part of an electronic and optical system that RCA installed and is operating on the S.S. American Mariner. The purpose of the equipment, for which the ship has been refitted, is to provide the most precise data yet obtained at sea on missile flights over a range extending from Cape Canaveral, Fla., to the area of Ascension Island. The project is sponsored jointly by the Advanced Research Projects Agency, Department of Defense and the Army Ordnance Command. A scientific staff—most of them RCA personnel—will operate the equipment and report on missile performance from descent from space to final plunge, the data to be shared by all branches of the armed services.

RCA Tmk(s) ®

RADIO CORPORATION of AMERICA

DEFENSE ELECTRONIC PRODUCTS
CAMDEN, N. J.



AMPHENOL *Quick-Crimp*

BNC CONNECTORS

CUT ASSEMBLY TIME *IN HALF!*

AMPHENOL's new *Quick-Crimp* Series BNC connectors* obsolete just about every other BNC now on the market. Here's why:

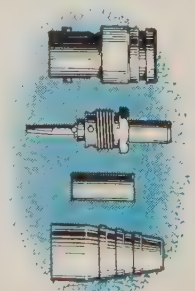
1 QUICK ASSEMBLY Only three basic parts (plus an optional boot) for you to assemble and crimp, as compared to as many as ten parts in a standard BNC! Assembly time is cut in half!

2 INCREASED RELIABILITY Critical assembly operations have been eliminated; inspection is easier, faster, reliable. Cable retention and strain relief is greatly improved. Connectors are weather-proof.

The *Quick-Crimp* family consists of 19 connectors: Plugs, Right Angle Plugs, Jacks, Bulkhead Jacks and Cable Terminations. *Quick-Crimps* mate with standard BNCs. Center contacts are gold-plated, have AMPHENOL's patented captivated contact** construction. Voltage rating is 500 V. peak. VSWR is low up to 10K mc.

*U.S. PATENT PENDING **U.S. PATENT 2,870,420

Body Assembly, Ferrule Clamp
Nut Assembly, Outer Ferrule and Boot
—Only Four Parts to Assemble!



AMPHENOL CONNECTOR DIVISION

AMPHENOL-BORG ELECTRONICS CORPORATION *Chicago 50, Illinois*

cannot be large enough to keep the heat loss from lagging behind the heat production of the body cells.

Effect of sweating hard to pin down

Another important mechanism for maintaining the proper $T_c - T_s$ gradient is the evaporative cooling of the skin through the excretion of sweat. Just how much good sweating does is very difficult to calculate— such elusive factors enter as the area of wetted skin, the vapor permeability of the clothing, the effective vapor pressure gradient between the skin surface and the boundary layer over it, the environmental temperature, and, last but not least, the portion of the sweat that actually vaporizes (much of the sweat we produce merely drops off our body, serving no useful purpose at all).[1]

Sweating again represents a "trade-off". Sweat is essentially an 0.5 per cent aqueous solution of salt. If it is produced at a rate exceeding the intake of salt and water in food and liquids, dehydration and salt depletion are inevitable. The loss of body fluid ultimately reduces the volume of circulating blood—an effect that is particularly grave in view of the difficulties of maintaining adequate blood flow to the skin that we have already described. The loss of salt also is harmful, for the sodium ion is essential for the normal functioning of nerve and muscle tissue. Most cases of heat collapse or exhaustion actually are due not to excessive body temperature but to the tremendous loss of water and salt involved in keeping the heat flow from the body at the proper level.

Operative conductance depends on T_a

Heat is also transmitted from the body by convection, conduction, and radiation, which make up the operative conductance (C_a). For all three of these processes, the gradient $T_s - T_a$ obviously must be positive. Since T_s normally is 91 deg F, any higher external temperature would tend to reduce all heat loss from the skin to that caused by sweat evaporation—unless there were an increase in T_s. There is such an increase initially as the blood flow to the skin is increased; however, we have al-

more on page 68

Write in No. 23 on Reader Service Card

How versatile **Cronaflex** Trademark streamlines production

Union Switch & Signal Division of Westinghouse Air Brake Company, Swissvale, Pennsylvania, has discovered that Du Pont CRONAFLEX saves time and expense in several different ways in the design and manufacture of automatic control equipment for railroads and pipelines.

First of all, diagrams of control systems do not have to be completely redrawn if they contain the basic elements. Instead, the basic data is drawn once and then photographically reproduced on CRONAFLEX as many times as necessary, and the variable additions added to meet the specific requirement.

When preparing wiring diagrams for complex systems, Union Switch & Signal starts with reproducible template prints that contain basic parts of a composite control system. On these the designer adds the required wiring information. Then he cuts out the unused elements and reproduces the selectively cut print on CRONAFLEX, which serves as the final tracing.

CRONAFLEX is also used to make accurate, legible reproduced tracings of valuable originals which due to age and use have developed poor contrast causing illegible reproductions.

In addition, CRONAFLEX helps this company put an accurate picture directly on metal or plastic parts, eliminating expensive layout time for machining operations. The material is spray-coated with a photosensitive emulsion, placed in contact with the layout drawing on CRONAFLEX, and exposed in a vacuum frame. After development the piece is engraved, punched or machined for use as part of a product or used as a template in punching operations, directly from the picture on the material. This is feasible because CRONAR* base of CRONAFLEX resists shrinking and stretching caused by changes in temperature and humidity.

Versatile CRONAFLEX can work profitably for you, too. For more information write E. I. du Pont de Nemours & Co. (Inc.), Photo Products Department, Wilmington *98,* Delaware. In Canada: Du Pont of Canada Limited, Toronto.

Unwanted elements of a drawing are cut from the composite print before reproducing on CRONAFLEX. This saves time spent in laborious eradicating.

CRONAFLEX is also used to make metal or plastic templates. Material is spray-coated with emulsion, then CRONAFLEX drawing is printed right on the surface

DU PONT
REG. U.S. PAT. OFF.

*CRONAR is Du Pont's registered trademark for its polyester photographic film base

This advertisement was prepared exclusively by Phototypography

Better Things for Better Living . . . *through Chemistry*

Write in No. 24 on Reader Service Card at start of Product Preview Section

A missile streaking through the sky . . . a ship plowing through the ocean swells . . . a submarine gliding through the depths . . . all guided with unerring accuracy by Autonetics' inertial navigation systems.

Twelve years ago development was under way on the first Autonetics' inertial autonavigator—a system to guide a supersonic missile to a distant target.

Since then, refined versions of this system have shown remarkable capability for guidance over, on and under the terrestrial surface in any craft, at any speed, under any conditions . . . a significant advance in the state-of-the-art.

It was an Autonetics' autonavigator that guided an aircraft on the first successful daylight cross-country flight by stellar-inertial autonavigation. Another version

Inertial navigation

easily passed the Navy's exhaustive sea tests aboard the USS Compass Island in 1957. And in 1958, Autonetics' systems guided the USS Nautilus and Skate on their historic voyages under the polar ice.

Today Autonetics is producing the systems to guide the Air Force's GAM-77 missile and the Navy's Polaris-carrying submarines. Its engineers are designing systems for the Minuteman intercontinental ballistic missile. Even more advanced systems will provide the accurate stellar-navigation data needed to guide man on his travels through Outer Space.

But the imaginative engineering that brought inertial navigation so far, so fast, is only half the Autonetics' story. New ideas had to be implemented by new manufacturing techniques. Many components of inertial autonavigators—gyroscopes, accelerometers and computer elements—called for precision that was once impossible. Now Autonetics has put it on the production line.

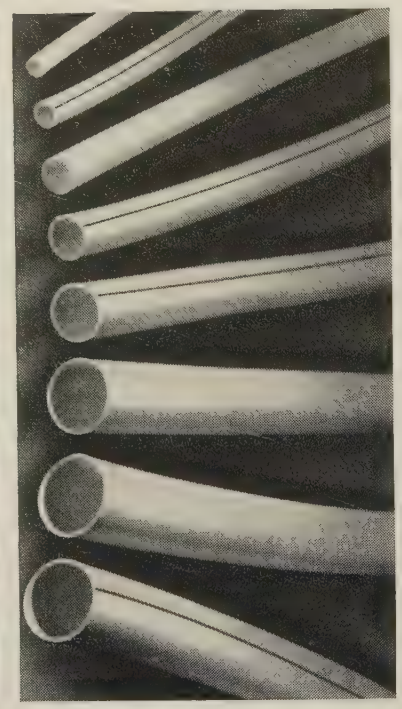
These are the achievements that have given here-and-now reality to inertial navigation . . . and have made Autonetics first in the field.

by Autonetics

A DIVISION OF NORTH AMERICAN AVIATION, INC., DOWNEY, CALIFORNIA • REGIONAL OFFICES: WASHINGTON, D. C. AND DAYTON, OHIO

INERTIAL NAVIGATION / ARMAMENT CONTROL / FLIGHT CONTROL / COMPUTERS AND DATA PROCESSING

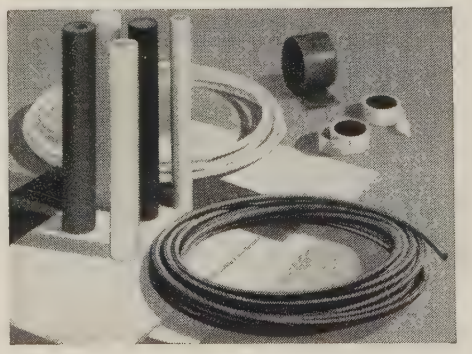
If the job calls for TEFLON* use R/M and be sure!



Minimize the risk of failure of a "Teflon" part or component at a critical point by getting it from Raybestos-Manhattan.

R/M has been in the forefront of "Teflon" development from the beginning. Our engineers *know* "Teflon" . . . its unique characteristics, its vast potentialities, how it can best serve the needs of a particular industry. Our production men have the know-how and complete plant facilities to follow through. You specify it; they fabricate it.

We understand the complexities of your problems—friction, extremes of temperature, the corrosive action of exotic fuels, etc.—and will give you all possible aid in designing, molding or machining the R/M parts or components you need. Make R/M your headquarters for all the "Teflon" products you need. Call upon your nearest R/M district office for the cooperation you require—or contact us direct.



R/M "Teflon" products for aircraft, missiles and space vehicles include thin-wall tubing (with or without identifying stripe); flexible wire braid covered "Teflon" hose; sheets, tape, rods and tubes; rods, sheets and tubes in certified and stress-relieved grades (X-ray films for sheets and rods are available); centerless ground rods held to very close tolerances.

**A Du Pont trademark*

RM

RAYBESTOS-MANHATTAN, INC.

PLASTIC PRODUCTS DIVISION FACTORIES: MANHEIM, PA.; PARAMOUNT, CALIF.

Contact your nearest R/M district office listed below for more information or write to Plastic Products Division, Raybestos-Manhattan, Inc., Manheim, Pa.

BIRMINGHAM 1 • CHICAGO 31 • CLEVELAND 16 • DALLAS 26 • DENVER 16 • DETROIT 2 • HOUSTON 1
LOS ANGELES 58 • MINNEAPOLIS 16 • NEW ORLEANS 17 • PASSAIC • PHILADELPHIA 3
PITTSBURGH 22 • SAN FRANCISCO 5 • SEATTLE 4 • PETERBOROUGH, ONTARIO, CANADA

RAYBESTOS-MANHATTAN, INC., Engineered Plastics • Asbestos Textiles • Mechanical Packings • Industrial Rubber
Sintered Metal Products • Rubber Covered Equipment • Abrasive and Diamond Wheels • Brake Linings
Brake Blocks • Clutch Facings • Laundry Pads and Covers • Industrial Adhesives • Bowling Balls

Write in No. 25 on Reader Service Card at start of Product Preview Section

ready seen that even a relatively small increase in T_s raises the body temperature (because of the decrease in $T_c - T_s$). *Figure 1* shows the roles of the various process of heat transmission.[2]

Combined effects must be considered

In considering the heat balance problem of crew members of hypersonic vehicles, we must remember above all that body temperature and hence the performance level are affected by *all* the processes we have discussed. There is little gained, for instance, by cooling the air in the cabin if the cabin walls are hot enough for positive radiant heat exchange. Similarly, hyperthermia (body temperatures exceeding the normal 99 deg F) will occur even at mild environmental temperatures if there is enough moisture in the air to preclude efficient sweat evaporation. Many "tolerance data" in the literature are useless to the design engineer because they are not related to all the parameters of human heat balance. (They may even be related solely to air temperature, which by itself is quite meaningless.)

Blockley has combined the various environmental effects on the heat balance in the so-called "operative temperature":[1]

$$(3) \quad T_o = (T_w C_r + T_A C_c) \times (C_o + C_r),$$

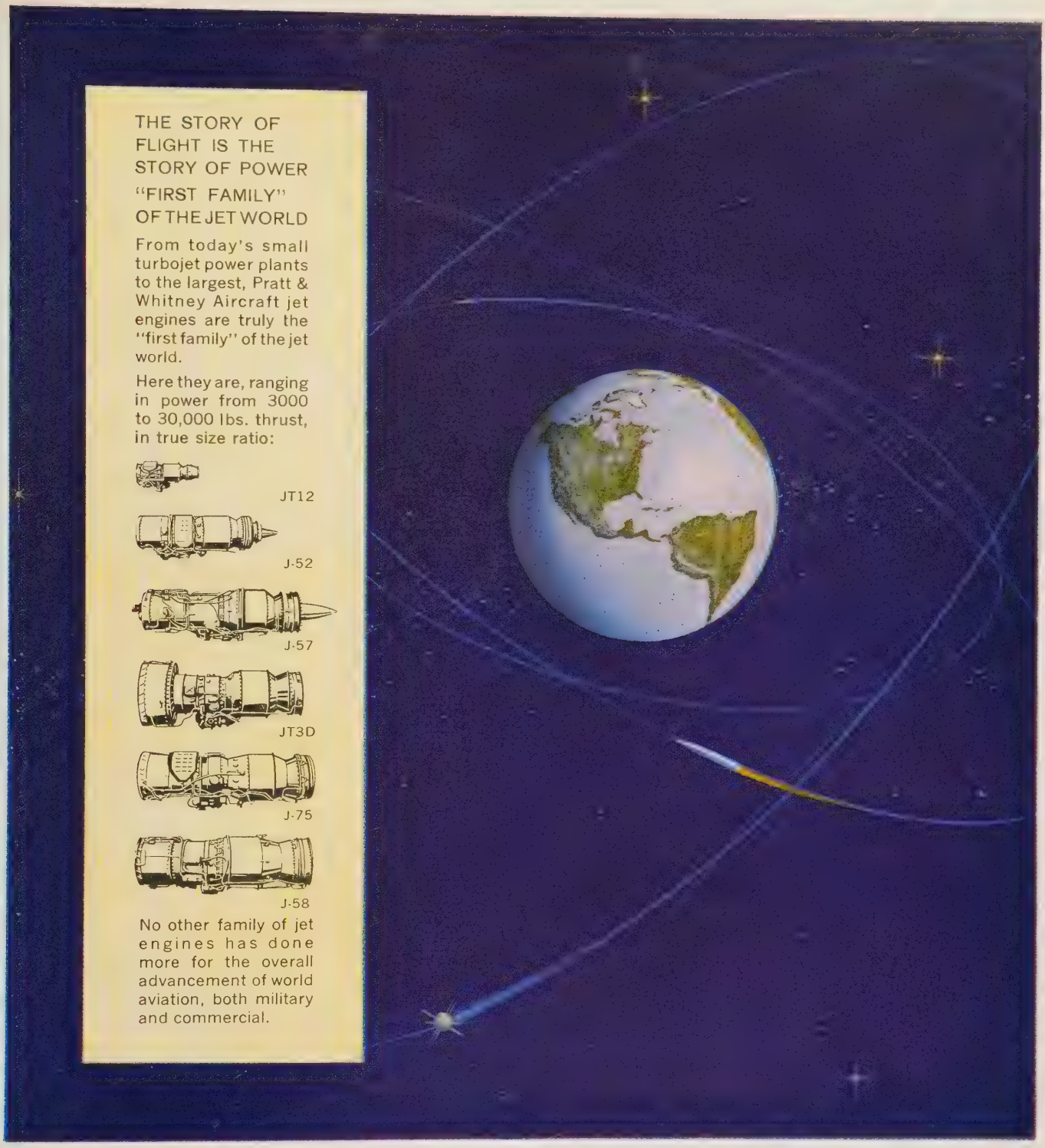
where T_w and T_A are the cabin wall and cabin air temperatures, respectively, and C_r, C_c, and C_o the radiant, convective, and operative conductances, respectively. The effects of humidity are expressed through the concept of "effective temperature", in which lines of "equal comfort" are located on psychrometric charts.[3] As T_o rises, $Q_m + Q_o$ becomes positive—heat is being stored in the body and the core temperature goes up.

Biothermal problems vary during the flight

During the various stages of a flight beyond the atmosphere, different biothermal problems are posed by a sealed cabin:

• During the countdown, we have the old problem familiar to anyone who has ever sat in an aircraft parked on the ramp in the hot sun—if there isn't enough cool

more on page 70


THE STORY OF FLIGHT IS THE STORY OF POWER
"FIRST FAMILY" OF THE JET WORLD
From today's small turbojet power plants to the largest, Pratt & Whitney Aircraft jet engines are truly the "first family" of the jet world.
Here they are, ranging in power from 3000 to 30,000 lbs. thrust, in true size ratio:
JT12
J-52
J-57
JT3D
J-75
J-58
No other family of jet engines has done more for the overall advancement of world aviation, both military and commercial.

POWER IS THE KEY!

Aviation has made rapid advances in its brief history. But only in recent years has man seriously envisioned the tremendously increasing speeds, altitudes and distances that are now within reach.

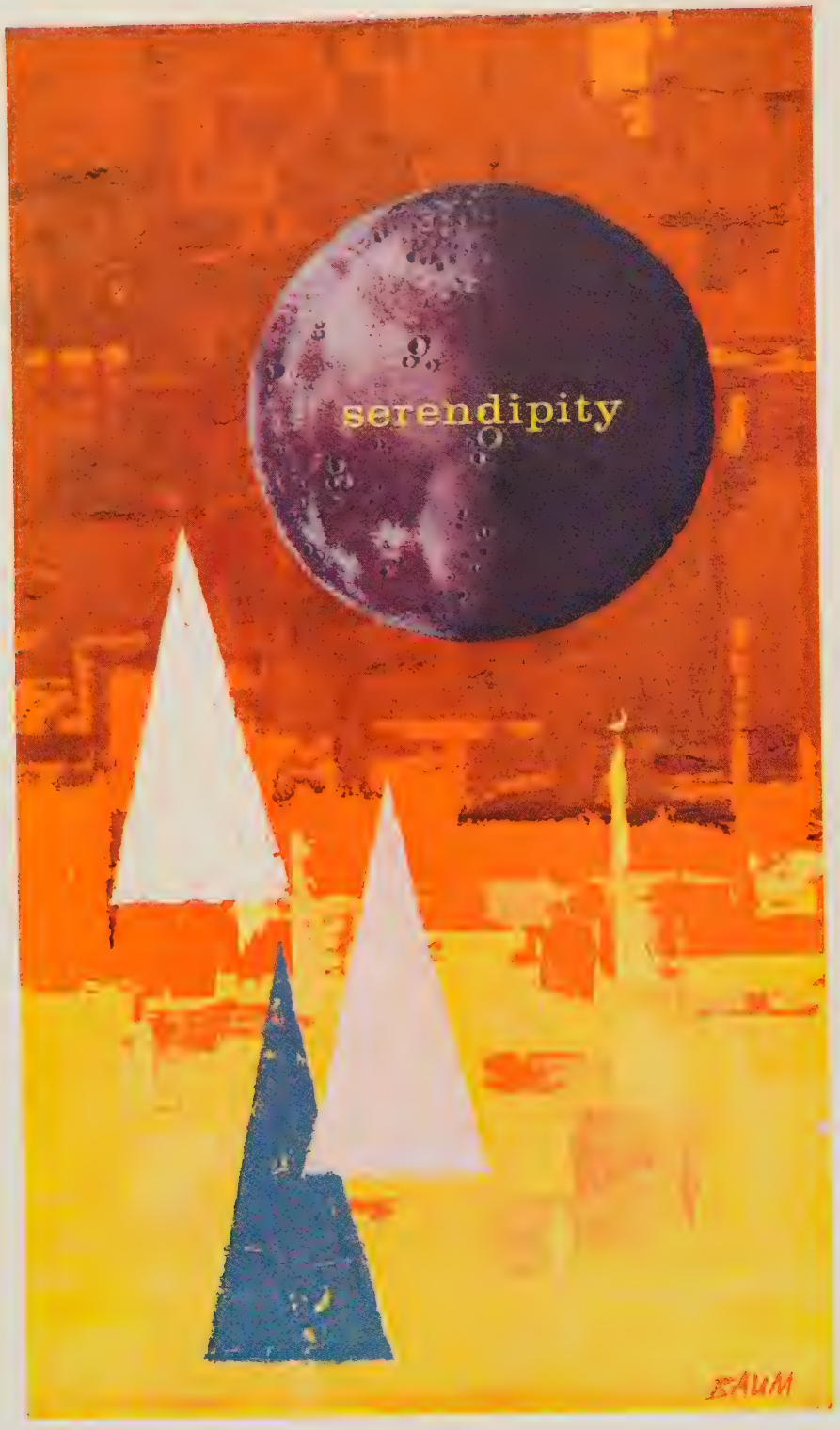
The key to this exciting prospect is power . . . dependable power, in forms or amounts adequate for any needs.

In this new era Pratt & Whitney Aircraft is continuing its traditional role of providing dependable power for flight, in whatever form it may take. For example, we have made significant advances in the fields of nuclear aircraft propulsion, solid rocket components, and liquid hydrogen rocket applications. We are also doing intensive work on even newer projects, such as storable propellant rockets, and power for space flight.

Flight Propulsion by **PRATT & WHITNEY AIRCRAFT**

East Hartford, Connecticut

A division of United Aircraft Corporation



transcending present knowledge . . . *creating new concepts in space science . . . a unique challenge for persons who seek intellectual stimulation and association, and are able to recognize and use the serendipity which awaits scientific discovery. At MARTIN-DENVER, post-Titan space programs now in progress offer the professional mind an opportunity for great personal advancement. Inquire immediately of N. M. Pagan, Director of Technical and Scientific Staffing, The Martin Company, P. O. Box 179 (AA-4), Denver 1, Colorado*

MARTIN
DENVER DIVISION

Check Employment Inquiry Form on Page 157

ventilating air, solar radiation can become decidedly uncomfortable.

• In orbit, the crew will live in a pure "radiation climate", in which the radiant exchange between hull, earth, and sun must be balanced. There will of course be no natural convection, and the conductivity of the cabin air will have to be corrected for changes in air density, which in turn depends on the changing cabin operating pressure.

• During re-entry, the thermal threat becomes critical, since a rather steep temperature gradient must be maintained across the cabin wall.[4] Control of the cabin air temperature (as affected by the heated cabin walls) is further complicated by the fact that the apparent system weight is changing.

Grashof function expresses air convection

All these physical effects are brought together in the so-called Grashof function *(Gr)* to express the convective properties of the cabin air:[5]

(4) $Gr = (g/32.2) \times (1.13 \times 10^{-2}/u^2T^3) \times (T_W - T)8p^2$,

where g is apparent acceleration (in ft/sec^2); u, viscosity at T; T, $0.5(T_W - T_A)$; T_W, internal cabin wall temperature; and p, internal cabin pressure.

In studying human performance under heat loading, tolerance time can be conveniently related to T_o as shown in *Figure 1*. This curve represents a limit—at any point above it, performance is uncertain.

The curve in *Figure 1* is limited to 250 deg F because at about this temperature there is a distinct change in human heat response. Below 250 deg F, we are mainly concerned with the "heat storage problem"—hyperthermia caused by excessive *body* temperature. Above 250 deg F, human tolerance is sharply limited because the *skin* temperature quickly rises to painful and/or damaging levels (before there is time for appreciable heat transfer into the body core).

Endurance over 250 deg F is very short

We have no adequate data about the period over which human beings can take operative temperatures over 250 deg F, but we do know the period apparently is very short indeed. Almost invariably,

more on page 72

When aluminum

Executive Aircraft

Commercial Aircraft

is part of your product

Private Aircraft

. . . check with ANACONDA ALUMINUM!

If your product demands aluminum to exact specifications—and you're not getting it—call on Anaconda! Custom production, combining precision control of the most modern equipment available with the craftsmanship of aluminum experts, assures you that Anaconda Aluminum always matches your product specifications precisely. And the flexibility of our modern plant facilities gives your orders fast action, prompt shipment.

Talk over your requirements for pig and ingot, coiled and flat sheet, extruded shapes, structurals, rod, bar and tubular products now with your local Anaconda Aluminum representative . . . or write our General Offices, Dept. SA-7, Louisville 1, Kentucky.

ANACONDA ALUMINUM®

Remember . . .

Every industry has one member who specializes in customer satisfaction

ANACONDA ALUMINUM COMPANY • GENERAL OFFICES, LOUISVILLE, KENTUCKY

Write in No. 26 on Reader Service Card at start of Product Preview Section

BLASTING Bolts INTO THE BLUE

CHANDLER

precision fasteners

In the unknown reaches of outer space . . . where accuracy and dependability count . . . you can count on precision-made Chandler fasteners for maximum resistance to vibration, fatigue and high temperatures.

Made from high carbon, alloy, super-alloy and stainless steels, Chandler cold-rolled fasteners are checked at every phase of production to assure absolute uniformity and conformity to customer specifications. For the aircraft industry Chandler produces high quality "AN", "NAS" and special aircraft engine bolts to meet individual requirements.

If you are looking for fasteners at a realistic price to meet your very special requirements, write us today.

8476-CH

Write today for your copy of CHANDLER PRECISION FASTENERS

CP chandler products corporation

1493 Chardon Road • Cleveland 17, Ohio

Write in No. 27 on Reader Service Card at start of Product Preview Section

high radiant heating is what causes problems above 250 deg F. *Figure 2* therefore relates skin temperature to time for various levels of radiant heating.[6] Pain is taken as the endpoint rather than actual burning of the skin. Whether or not the skin is damaged irreversibly depends on a temperature-duration function,[7] but it is clear that under sudden heating severe pain can disable even a person who remains physically uninjured, or "physiologically normal."

Trend is toward "shirt sleeve" conditions

Though we cannot go into any detail here on the protective value of clothing, it should be noted that even a relatively small amount of clothing is of significant value, since infrared radiation has limited penetrative properties. The ventilated suit has undeniable advantages, and there can be no doubt that it will play an important role during the early stages of manned space flight. However, as flight times increase, the trend will be more toward "shirt sleeve" conditions inside the crew compartment.

One problem of human heat tolerance that is still unresolved is that of recovery. What determines the rate of recovery from hyperthermic exposure? Are the effects of repeated but short exposures cumulative? Is heat acclimatization feasible? Would cooling immediately before re-entry increase the crew's heat tolerance? Once these questions are answered, we will be on much firmer ground in flight programing and in estimating the chances of survival.—End

References—(1) W. V. Blockley, J. W. McCutchan & C. L. Taylor, "Prediction of Human Tolerance for Heat in Aircraft: A Design Guide"; WADC Tech. Rep. 53-346 ('54). (2) J. D. Hardy & E. F. DuBois, Jr., "Basal Metabolism, Radiation, Convection and Vaporization at Temperatures of 22 to 35 Deg C"; *J. Nutrition,* 15/477 ('38). (3) C. P. Yaglou, "Indices of Comfort" (in "Physiology of Heat Regulation"); Saunders ('49). (4) E. T. Carter & M. W. J. Bell, "Biothermal Aspects of Re-Entry from Extra-Atmospheric Flight"; Paper 704-38, ARS Annual Meeting '58 (New York City). (5) F. J. Lyons, "Heat Transfer Methods for High Speed Vehicles"; Rep. NA 58H-71, NAA-Columbus ('58). (6) J. D. Hardy, "Summary Review of the Influence of Thermal Radiation on Human Skin"; Rep. NADC-MA-5415, USN Air Dev. Center ('54). (7) A. R. Moritz & F. C. Henriques, Jr., "Studies of Thermal Injury: Relative Importance of Time and Surface Temperature in Causation of Cutaneous Burns"; *Amer. J. Path.;* 23/695 ('47).

Whether you are an engineer, architect, designer or draftsman, two things are essential for your success:

1. ***The native ability to create or interpret.***
2. ***The "golden touch" to transform your grey matter into black matter on paper or cloth.***

CASTELL can neither add nor subtract from your native ability, but it can impart the "golden touch" to your eager, sensitive fingers. It gives correct tonal value to every line and shape your brain transmits to your hand.

Made of the world's finest natural graphite, CASTELL tests out at more than 99% pure carbon. Contains no smudgy foreign substance to give the false illusion of black.

Let CASTELL be your perfect "transfer" agent. It costs no more to work with the world's finest drawing tools—CASTELL wood pencils in 20 superb degrees, 8B to 10H, imported CASTELL leads and new functional design LOCKTITE TEL-A-GRADE holders with the bulldog grip clutch. Order from your dealer today.

Choose from: #**9000** CASTELL Pencil. #**9007** CASTELL with Eraser. #**9800SG** LOCKTITE TEL-A-GRADE Holder with new functional spiral grip and degree indicating device. #**9030** CASTELL Refill Lead matching #9000 pencil in quality and grading, packed in reusable plastic tube with gold cap. Other styles and colors of pencils, holders and refill leads.

Castell Leads and Pencils draw on all surfaces, including Mylar-based polyester drafting films. Give perfect lines, easy to erase —excellent reproduction.

BACKED BY NEARLY 200 YEARS UNINTERRUPTED MANUFACTURING EXPERIENCE — SINCE 1761

FABER-CASTELL

Copyright 1959

A.W.FABER-CASTELL Pencil Co., Inc.
Newark 3, N. J.

Write in No. 28 on Reader Service Card at start of Product Preview Section

titeflex flexible hose made for the toughest design jobs

It is now possible to design fluid transfers that would have been impossible until recently. Here are examples of TITEFLEX advances in the flexible hose field:

ITEM: Springfield "400"* Teflon** hose in diameters to 2" . . . convoluted by an exclusive process to produce unique flexibility . . . minimum bend radius only 3⅓ times hose diameter!

ITEM: "Zero-motion" braiding . . . a TITEFLEX process that also reduces chafing of braid wire, and wear to minimum. Elongation or contraction at operating pressure less than ½ of 1%!

ITEM: Springfield "140" Teflon Hose Assemblies . . . with reusable fittings . . . factory or field installed!

ITEM: Springfield "110" Teflon Hose Assemblies . . . guaranteed against fitting blow-off at their specified temperatures and pressures!

TITEFLEX is found wherever design problems are toughest. Details and specifications are as close as your phone. Your TITEFLEX distributor is in the yellow pages, or contact TITEFLEX direct.

titeflex

*T.M. of Titeflex, Inc., Patent Pending **Reg. T. M. of duPont

titeflex inc. springfield mass. PACIFIC DIVISION • SANTA MONICA • CALIF

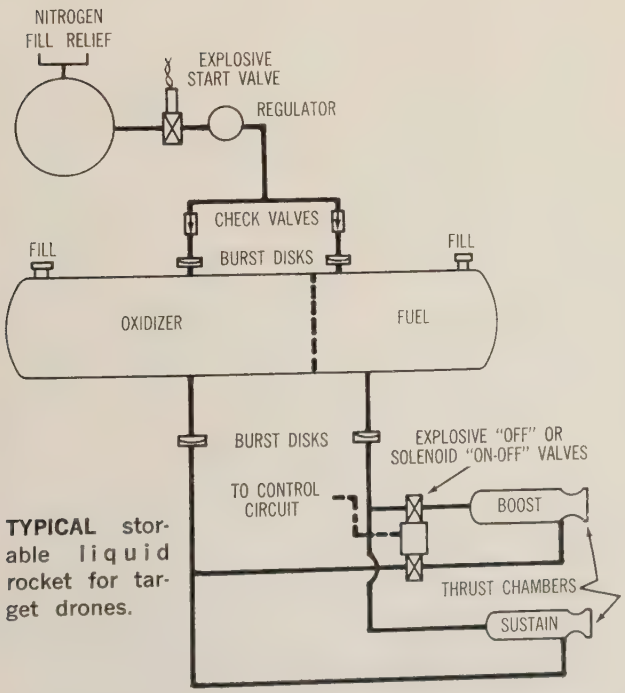
Write in No. 29 on Reader Service Card at start of Product Preview Section

Storable liquid propellants

look good for drone rockets

This is the second article in a two-part series on choosing powerplants for target drones. It outlines the basic requirements for drone propulsion and shows how liquid rockets meet them. The first article in this series compared liquid rockets and ramjets (May 1959, p. 61).

by R. P. Reul, Branch Engineer, Radioplane Div., Northrop Corp.*



TYPICAL storable liquid rocket for target drones.

STORABLE liquid propellant rocket engines have cracked the monopoly—based on reliability and instant readiness—that the solid propellant rockets have enjoyed over the last two years. For supersonic target drones, the storable liquid engines look especially good.

Their basic design is quite simple (see *Schematic*). The most critical component is a regulator in the propellant tank pressurization circuit. All other controls are on-off shutoff and check valves.

A conventional nitrogen pressure-feed system is quite adequate for drone rocket engines, since design thrust and total impulse levels are low. There is no need for a turbopump feed (which in this application would be only excessively heavy and costly).

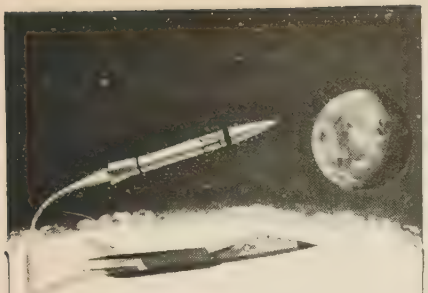
Pre-packaged storable liquid rockets for certain short duration missiles are pressurized by a solid propellant gas generator. Such a unit weighs about one-third less and has a 90 per cent smaller volume than an equivalent nitrogen system.

Unfortunately, the advantages of solid gas generators do not apply as readily to drone propulsion system—at least not right now. So far gas generator designs have not been sufficiently advanced to handle burning times of several minutes. All indications are that it will take a major and costly development program to come up with a suitable unit. Other problems are:

- boost-sustain rocket controls of the on-off type would require a fluctuating burning rate, a pressure dumping system, or a regulator able to handle rocket exhaust products;
- the pressurizing charge would probably have environmental temperature limitations more critical than those of rocket propellants;
- operational flexibility and propulsion system growth potential would be greatly curtailed, since propellant tank pressures could not be readily altered to meet changing thrust requirements.

*Propulsion Unit Analysis, Radioplane Div., Northrop Corp., 8000 Woodley Avenue, Van Nuys, Calif.

more on next page



Flight Control Aerodynamicists

Flight Control Systems Engineers are needed immediately to develop control systems for advanced aircraft and missile projects. Openings exist in both our Aerodynamics and Electro-Mechanical Sections.

These engineers will integrate flight control and stability augment systems with aerodynamic configuration development to obtain desired dynamic flying qualities. Experience in solving problems with five and six degrees of freedom, dynamic stability analysis, servo-analysis, feedback systems, prediction of aerodynamic stability derivatives or related areas desired.

No need to commute. Live near your job in suburban Columbus — a good place to raise your family and pursue your technical career.

Send your resume to:
H. Keever
Engineering Personnel Manager, Box
North American Aviation, Inc.
Columbus, Ohio

THE COLUMBUS DIVISION OF

NORTH AMERICAN AVIATION, INC.

Home of the T2J Jet Trainer and the A3J Vigilante

Acceptable Storage Bipropellant Combinations for Drone Rockets[1]

Fuel	Oxidizer	Spec Impulse Range (sec)[2]	Oxidizer-Fuel Ratio	Specific Gravity	Cost per Pound	Remarks
Hydrazine[3]	inhibited red-fuming nitric acid (IRFNA)	251-278	1.40	1.26	$1.29	expensive
Unsymmetrical dimethyl hydrazine		242-268	2.6	1.23	$0.72	expensive
Hydyne (UDETA)		240-265	2.62	1.27	$0.81	expensive
Mixed amines (MAF)		236-261	2.80	1.29	$0.45	high viscosity @ low temperature
Trimethyl amine (TMA)		230-254	3.3	1.14	$0.13	low density
Hydrazine[3]	chlorine trifluoride[4]	269-298	2.45	1.45	$3.35	very expensive; additives to ClF_3 needed for use with other fuels
Hydrazine[3]	bromine pentafluoride[4]	248-274	2.8	1.78	$3.74	very expensive; performance problematical—firing experience needed

(1) All hypergolic at all altitudes, suitable for operation from —65 to 160 deg F, and acceptable in regard to vapor pressure, corrosion, and decomposition. (2) For chamber pressures of 200-300 psia and altitudes from 40,000 to 100,000 ft. (3) Hydrazine requires additives to depress its freezing point from +35 to —65 deg F. In the process it loses some specific impulse with present additives. (4) For future use.

All in all, a nitrogen pressurizing system is preferable at this time. However, solid or liquid propellant gas generators should definitely be considered for future applications.

Rocket chamber pressures should be kept to about 200-300 psia. This is high enough to insure stable combustion and reasonably good performance, but low enough to provide for appreciable growth potential.

Reliability important for pressure regulators

Propellant tank pressures will vary from 150-200 per cent of chamber pressure, depending upon system pressure drops. Care should be taken that pressure loads on integral tankage do not greatly exceed other structural loads. The overall system otherwise suffers a weight penalty.

Nitrogen pressure should normally not exceed 3000 psia (for the convenience and economy of loading with existing facilities). Higher pressures permit greater packing density, but without any significant weight savings.

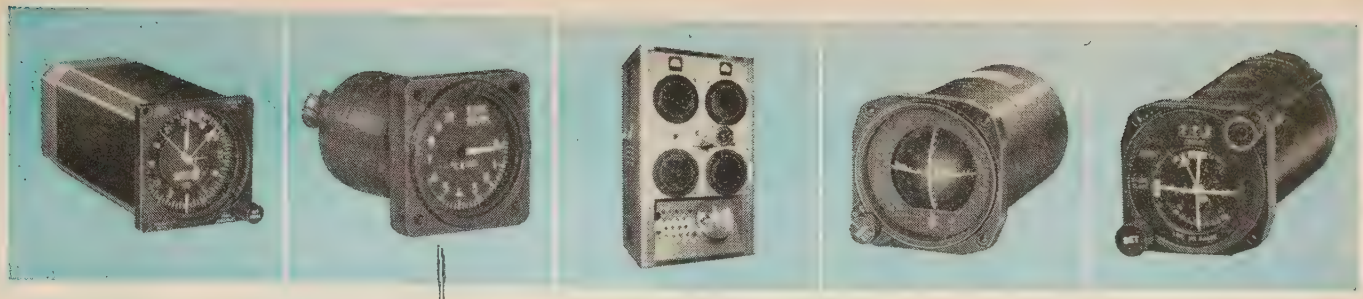
Pressure regulators should be standard commercial units wherever possible. Within reasonable limits, proven reliability is more important than size or weight.

Normally the storable liquid bipropellant engine uses a regeneratively cooled thrust chamber. In most cases, the oxidizer is also the coolant. The nozzle may be integral with the chamber and similarly cooled, or it may be an uncooled insert.

The number of thrust chambers is frequently related to the number of desired thrust levels. In general, a single, multiple-level chamber has a compromise expansion ratio and is less efficient than a chamber designed for a specific level.

The maximum thrust ratio with a single chamber is about 3. This

more on page 78

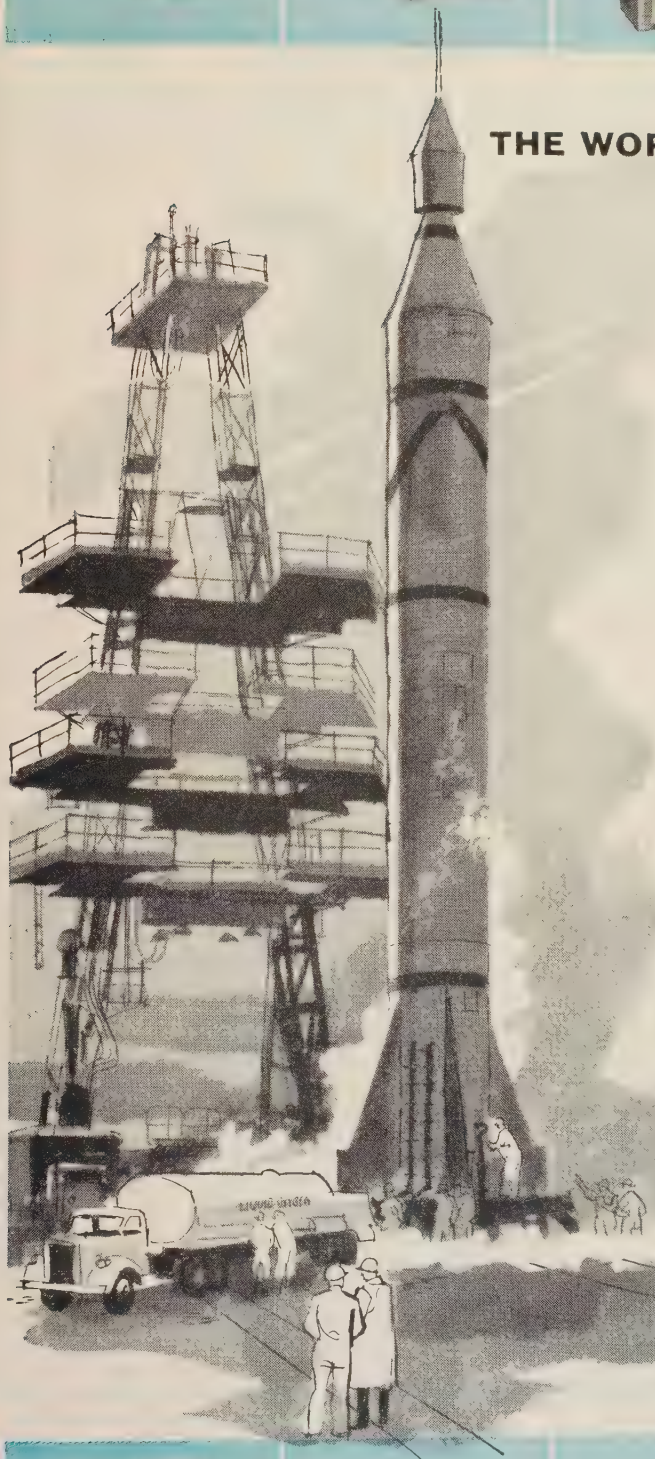


THE WORLD'S MOST CAPABLE MONITORS...

in the air...

on the ground...

in space



Weston brings matchless experience to the development and production of instruments, components and systems of proved reliability

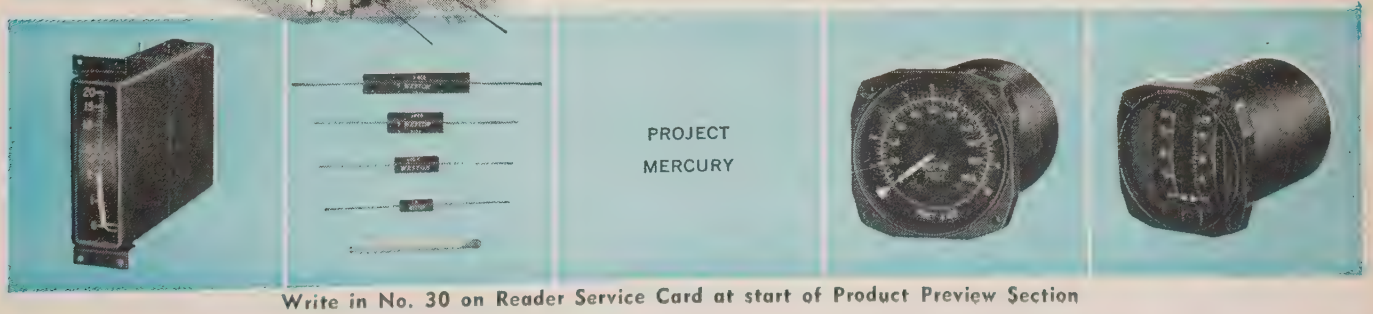
Please direct your inquiries to the Weston representative nearest you . . . or write to Weston Instruments Division of Daystrom, Inc., Newark 12, N. J. *In Canada: Daystrom Ltd., 840 Caledonia Road., Toronto 19, Ont. Export: Daystrom Int'l., 100 Empire St., Newark 12, N. J.*

WESTON *Instruments*

WORLD LEADER IN MEASUREMENT AND CONTROL

NAVIGATION INSTRUMENTATION • ENGINE INSTRUMENTATION • ATTITUDE AND CONTROL INSTRUMENTATION • COMMUNICATIONS INSTRUMENTATION • COMPUTING EQUIPMENT • GROUND SUPPORT EQUIPMENT • SOLID STATE DEVICES • MINIATURIZED ASSEMBLIES • TELEMETERING INSTRUMENTS • PROJECT MERCURY

A DAYSTROM UNIT



PROJECT MERCURY

Write in No. 30 on Reader Service Card at start of Product Preview Section

Unacceptable Propellants for Storable Drone Rocket Systems

	Use	Primary Reason for Rejection
JP-X	fuel	not hypergolic under all conditions; problematical combustion stability
hydrazine	fuel	high freezing point (suitable if freezing point depressant is developed that does not excessively degrade performance)
anhydrous hydrogen peroxide	oxidizer	high freezing point; limited storage capability
90% hydrogen peroxide	oxidizer	high freezing point; poor storage capability
nitrogen tetroxide	oxidizer	high freezing point; limited firing experience
perchloryl fluoride	oxidizer	excessive vapor pressure; very limited firing experience

hush-hush?

If you're now involved, or becoming involved, in hush-hush projects, you know how vital it is to have sources who can deliver on time, to rigid specifications. That's why it's important to constantly investigate and compare **new** sources — **to be sure!**

Cleveland Tool and Die Company has the capacity, ability and facilities* to insure your success. We're precision **specialists** in the manufacture of component mechanisms, sub assemblies, gages and fixtures . . . in custom machining, boring and grinding.

We've performed an important part in such exotic projects as the Shippingsport atomic reactor, the U.S.S. Nautilus, Redstone Arsenal, and Princeton's new synchrocyclotron. **When you talk to CTD, you know you're talking to qualified, dependable people.**

Please include CTD when getting your next quotations **. . . to be sure!**

George Banko
President

CLEVELAND TOOL & DIE CO.

1745 Eddy Road • Cleveland, Ohio

*We've prepared a little brochure for your files, telling the CTD precision story, and listing our equipment. Drop us a line.

Write in No. 31 on Reader Service Card at start of Product Preview Section

is far below the ideal ratio that would minimize total impulse for various target missions. Furthermore, the increase in propellant tank pressure becomes even greater than the increase in thrust, so that tankage weight becomes prohibitive.

Multiple thrust chambers, used for different thrust levels, keep propellant tank pressures and weights to a minimum. Sustain stages can be fired at launch to contribute to the total boost thrust.

Propellant control valves should be commercially available units of the explosive "off" type or the solenoid "on-off" variety. Variable-thrust controls are more flexible but impose prohibitive reliability cost penalties.

To insure maximum operational safety of these propellant controls, the following additional components are normally required:

- a time delay circuit or some other arrangement to guarantee that the vehicle will be clear of operating personnel or the launching aircraft when the rocket engine is started;
- a normally closed nitrogen control valve of a type that precludes leakage, so that the engine can never be prematurely started;
- a nitrogen fill-relief valve for ready pressurization or de-pressurization with complete safety and quick determination of the existing pressure level;
- burst diaphragms at the inlets and outlets of each propellant tank that provide positive initial seals and are selected to rupture at a tank pressure midway between the maximum storage pressure and minimum operating level.

Few propellants are good all around

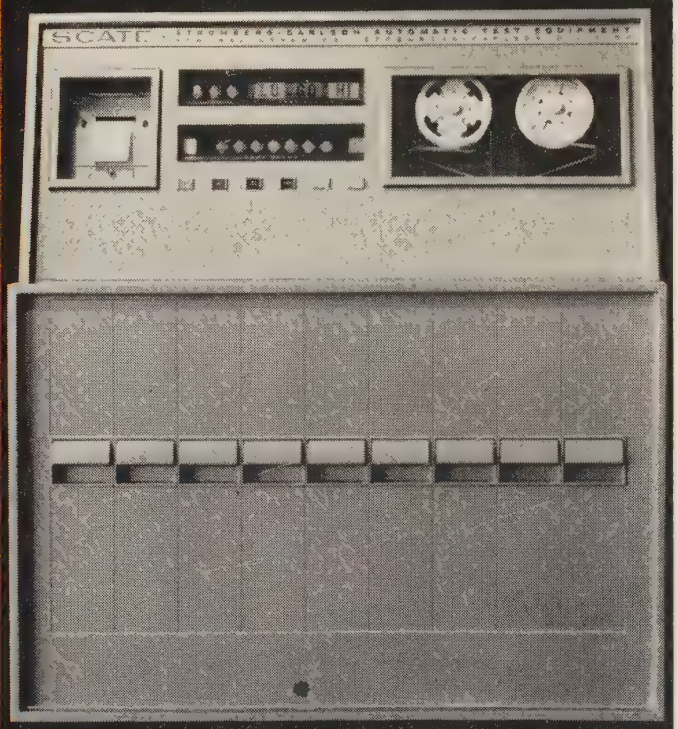
Of the various propellants that are considered storable, only one oxidizer—inhibited red-fuming nitric acid—and a handful of fuels qualify in all respects (see *Table*). Two other oxidizers, chlorine trifluoride and bromine pentafluoride show considerable promise. Their chief drawbacks are high cost and meager firing experience.

Hydrazine requires additives to depress its normal freezing point of +35 deg F to —65 deg F. Suitable additives are available, but they slightly reduce the specific impulse.

The basic requirements for stor-

more on page 81

A TALENT FOR WEAPONS TEST EQUIPMENT



AVAILABLE NOW FOR ANY WEAPONS SYSTEM: SCATE—Stromberg-Carlson Automatic Test Equipment

- Completely solid state; modular.
- Punched Mylar tape with photoelectric reader programs tests at rates up to 7,000 bits per second.
- Tests any weapons system, component or sub-assembly.
- Follows weapons system from prototype to operational status.
- Self-checking; self-calibrating.
- Detailed fault location down to the smallest resistor.
- Provides rapid HI-GO-LO and numerical evaluation as well as permanent printed record.
- Reduces cost and time of designing test equipment for each individual requirement . . . because most modules are standard.
- In a typical case, SCATE has reduced a 12-hour manual testing program to less than 5 minutes—a reduction of over 99%.

Today's SCATE system—currently in production for an advanced weapons system—is equally applicable to those of tomorrow.

H. C. Sager, Manager of Sales, is available to discuss your specific application. Literature on request.

Engineers with experience in the above area may contact the Manager of Technical Personnel at the address below.

STROMBERG-CARLSON

A DIVISION OF GENERAL DYNAMICS CORPORATION
1400 NORTH GOODMAN STREET • ROCHESTER 3, N. Y.
ELECTRONICS AND COMMUNICATION FOR HOME, INDUSTRY AND DEFENSE

Write in No. 32 on Reader Service Card at start of Product Preview Section

PORT OF EMBARKATION

In the decade of missilery ahead, prime contractor capability must go far beyond the requirements of hardware design and manufacture. New experience and facilities are now required in the increasingly critical launching phase—from ground handling and testing to countdown and data control.

Martin's Cocoa Division is the first organization of its kind devoted exclusively to this specialized area. Accomplishments have already established new operational standards at Cape Canaveral, one of the two U.S. ports of embarkation for the major space events of the decade ahead.

An example of the latest development in electronic fail-safe launching equipment is the new Martin Master Operations Control [MOC] system, which automatically monitors count-down procedures in the test firing of research and development-type TITAN missiles. With equipment such as this, TITAN launchings have achieved unheard-of performance reliability.

able liquid propellants used in a target drone rocket are:

- a minimum delivered specific impulse range of 230-260 seconds at a chamber pressure range of 200-300 psia and an altitude range of 40,-100,000 ft;
- no freezing or excessive viscosity down to —65 deg F;
- compatibility with normal tank materials such as weldable aluminum alloys and steels throughout the full military temperature range for a storage period of five years (with the maximum storage pressure due to both vapor and decomposition during this period not exceeding 200 psia at a storage temperature of 160 deg F);
- hypergolic ignition and stable burning at all altitudes over the full chamber pressure range and shutdown and restart without explosion.—End

books

Rockets & Satellites, edited by Dr. L. V. Berkner. A series of papers by leading scientists dealing with various aspects of IGY rocket and satellite programs are presented. Countries represented include Australia, France, Canada, United States, United Kingdom, and the USSR, Pergamon Press, Inc., 122 E. 55th St., New York 22, N.Y. $25.

Application of Atomic Engines in Aviation by G. N. Nesterenko, A. I. Sobolev and Yu. N. Sushkov. This is a translation by Technical Documents Liaison Office, Wright-Patterson AFB, of a recent ('57) text on the state-of-the-art in airborne nuclear powerplants. U.S. Dept. of Commerce, Office of Technical Services, Washington 25, D.C. $3.

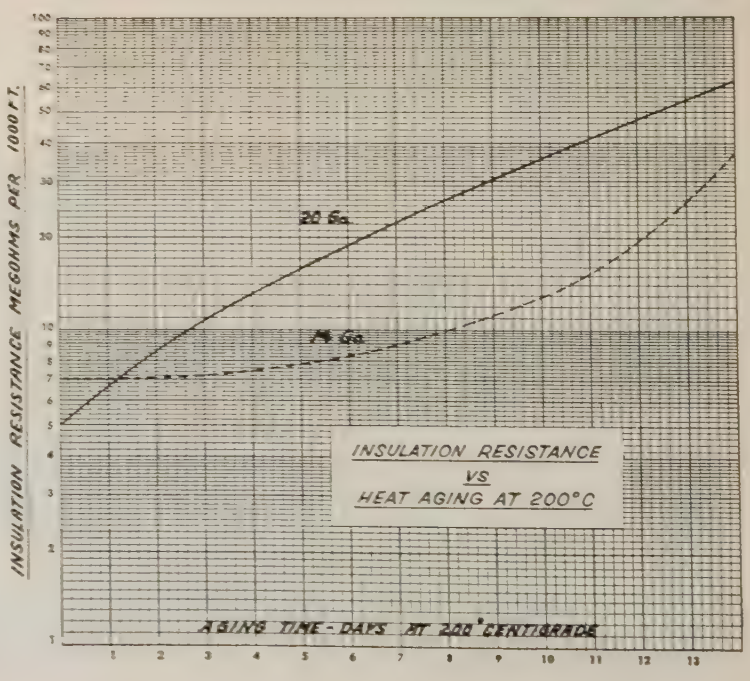
An Introduction to the Principles of Infrared Physics, by Askey, Hochheimer, et al. A broad brush picture of the state of the art is presented by members of the infrared radiation staff of Hayes Aircraft. Hayes Aircraft Corp., P.O. Box 2287, Birmingnam, Ala. $1.50.

CONVAIR B-58 subjects wire components to normal operation temperatures ranging from 350°F to –65°F. New silicone-insulated wire more than meets these and other aircraft and missile requirements.

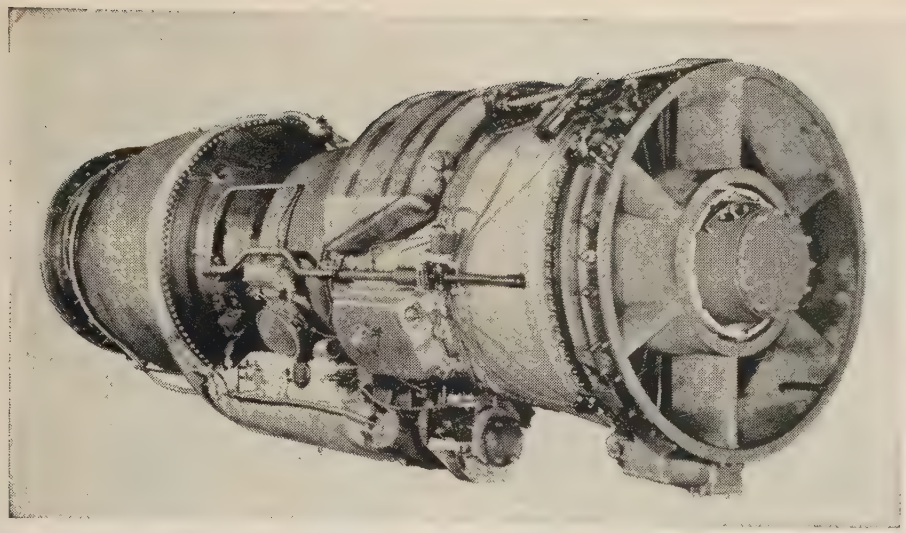
Silicone wire provides best answers for extreme heat, cold, corona, radiation, cold flexing

Looking beyond normal conductor changes and developments, Auto-Lite engineers are constantly developing and improving materials and processes for wire insulation. New materials include silicones, tetra-fluoroethylene, fluorinated ethylene propylene, polyvinyl chloride, nylon, and improved organic elastomers. These materials are providing excellent solutions to today's wire problems.

Silicone-rubber insulation is an outstanding example of these materials. Silicones have opened an entirely new field in the manufacture of wire and cable. The unique properties of the silicone compounds make it possible to have flexible insulated wire operating through a temperature range impossible to attain with other synthetic elastomers.



Graph shows a substantial improvement in Insulation Resistance values after heat aging of silicone-insulated wires. Tests were run on specimens having a glass overbraid saturated with high-temperature lacquer. Also, dielectric strength of silicone compounds remains relatively stable through a temperature range of 25° to 250°C.



HEAT AGING FROM EXPOSURE TO EXTREME TEMPERATURES quickly renders most common organic insulation materials ineffective. The usual heat-resistant materials—mica, asbestos, etc.—because of their lack of flexibility and poor moisture resistance, are difficult to maintain. Silicone-rubber compounds are now available which give excellent performance in continuous operation at temperatures to 500°F.

ANOTHER PROBLEM is the normal operation of aircraft at temperatures down to –80°F. Here plastic and rubber insulations freeze to a glass-like hardness and flake off, especially under severe conditions of vibration. Tests with new materials, again silicones, give outstanding results down to –130°F, far beyond what would ever be encountered in aircraft.

AT HIGH ALTITUDES, silicones are highly effective because of their resistance to the deteriorating effects of corona and arcing. Corona resistance approaches that of mica. In addition to high arc resistance, silicone insulation forms no carbon path regardless of the temperature.

AMERICA'S FOREMOST WIRE RESEARCH LABORATORY is operated by the Auto-Lite General Products Group at Port Huron, Michigan. Here, space-age wire problems have already become routine. This laboratory has the distinction of being completely equipped to perform all qualification tests on wire for military specifications. The facilities and personnel of this laboratory are available to serve all Auto-Lite wire customers.

Where better to direct your aircraft wire problems than to the leader in the aircraft wire field? Auto-Lite has a vast fund of answers to common problems and an outstanding ability to solve the remainder. Write, stating your problems, to . . .

AUTO-LITE®

GENERAL PRODUCTS GROUP

WIRE AND CABLE DIVISION • TOLEDO 1, OHIO

Plants at: Port Huron, Michigan, and Hazleton, Pennsylvania

Write in No. 33 on Reader Service Card at start of Product Preview Section

CHR ANNOUNCES M-777 A NEW HIGH STRENGTH SILICONE RUBBER

100% Stronger Than "High Strength" AMS 3345

M-777 is an exclusive CHR development offering a combination of properties unmatched by any other silicone rubber. This new compound has physical strength equal to good general purpose organic rubber and may be used in applications where high tear strength or abrasion resistance is required.

M-777 doubles many of the original physical properties of AMS 3345. It is unaffected by time, weather, sunlight or ozone — remains flexible at −105°F — resists heat up to 500°F — and has good electrical insulation qualities. Typical properties are listed below:

M-777 can now be specified for extrusions, moldings, extruded and spliced parts, or in combination with metals, reinforcing fabrics or with Teflon* bonded to the surface.

PHYSICAL PROPERTIES				
	As Received Properties	Dry Heat Resistance Aged 70 hours /400°F	Compression Set 70 hrs/300°F Percent of original deflection	Low Temperature Flexibility
M-777	Durometer Shore A 50 Tensile Strength, psi 2100 Elongation, % 600 Tear Strength, psi 325	Durometer Change + 8 Tensile Change − 20 Elongation Change − 20	45	−105°F
AMS-3345	Durometer Shore A 50 ± 5 Tensile Strength, psi 1000 Elongation % 500 Tear Strength, psi 150	Durometer Change 0 to + 20 Tensile Change − 50 Elongation Change − 40	73	−105°F

CHR has made many important contributions in the development of silicone rubber compounds and techniques. The first truly high strength silicone rubber was introduced by CHR.

M-777 with 2100 tensile and over 300 tear strength, psi, considerably broadens the possible usage of silicone rubber and adds a new dimension to its many unique advantages. We invite your inquiries.

CHR

COHRlastic Aircraft Products: SEALS • COATED FABRICS

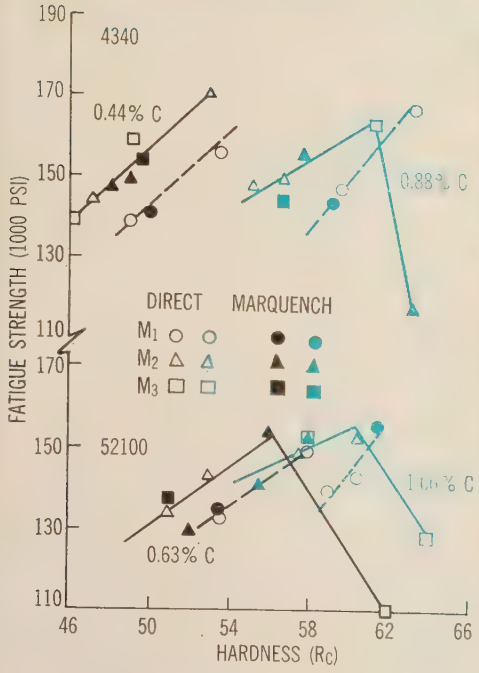
CONNECTICUT HARD RUBBER COMPANY

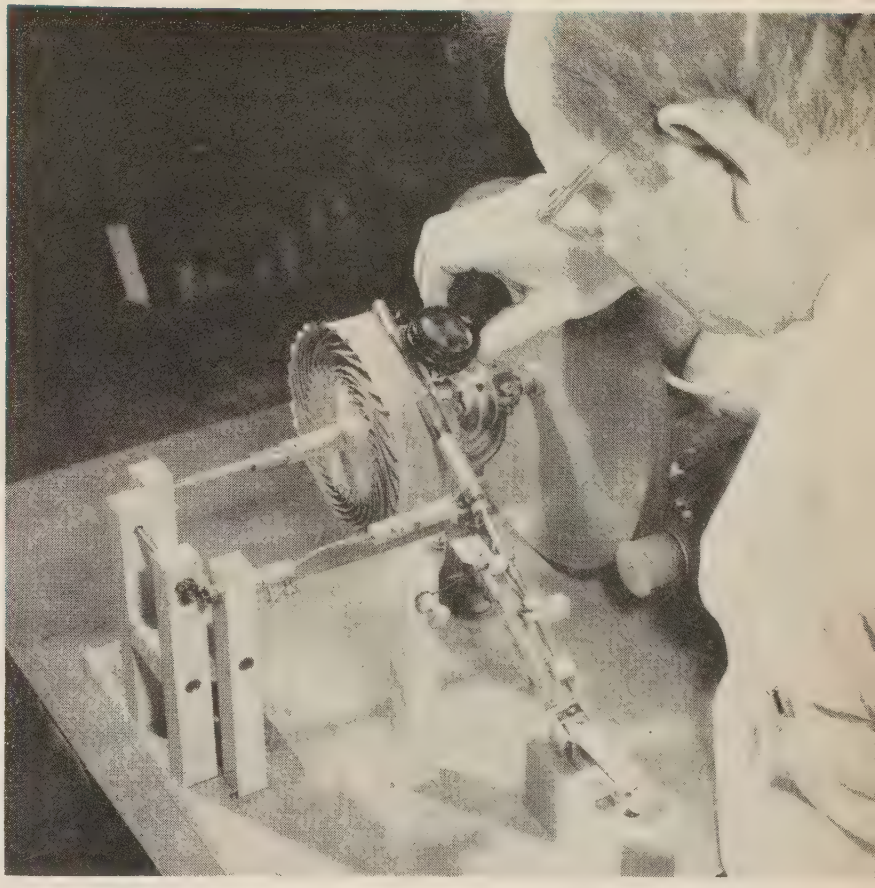
Main Plant • New Haven 9, Connecticut

CHR Sales Offices • Atlanta • Los Angeles • St. Louis • Seattle

* du Pont T.M.

Write in No. 34 on Reader Service Card at start of Product Preview Section





HARDNESS vs fatigue strength (above) to 10^5 cycles. Solid curves represent refrigerated specimens; dashed curves unrefrigerated ones. Right: NBS apparatus for polishing of metal specimens. Reduced section is polished parallel to the specimen's longitudinal axis.

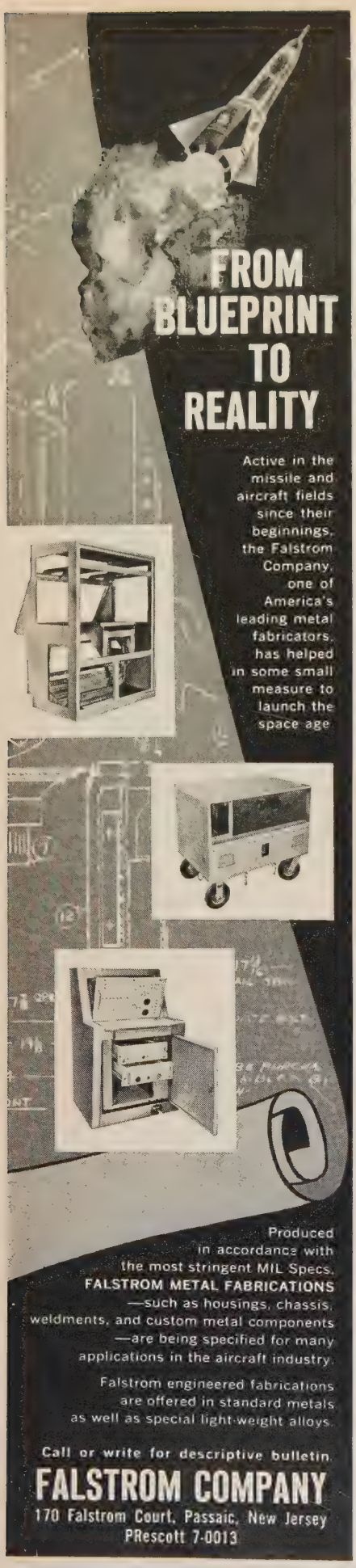
Microstructure affects steel fatigue strength

With high strength steels receiving increased attention for such critical parts as missile casings, recent NBS studies that shed new light on the fatigue phenomena of these materials assume prime importance. These studies indicate that retained austenite in the matrix of these steels has a major effect on fatigue strength.

WHAT causes fatigue in high strength steels? This question has become increasingly important with the wider use of these steels for critical missile and aircraft parts.

As researchers at the National Bureau of Standards, Washington 25, D. C., point out, though fatigue phenomena have been studied for many years, little work has been done on some of their metallurgical aspects. As a result, there's a lot of disagreement on the effect of metallurgical structure on steel fatigue strength.

more on next page


FROM BLUEPRINT TO REALITY
Active in the missile and aircraft fields since their beginnings, the Falstrom Company, one of America's leading metal fabricators, has helped in some small measure to launch the space age
Produced in accordance with the most stringent MIL Specs, FALSTROM METAL FABRICATIONS —such as housings, chassis, weldments, and custom metal components —are being specified for many applications in the aircraft industry.
Falstrom engineered fabrications are offered in standard metals as well as special light-weight alloys.
Call or write for descriptive bulletin.
FALSTROM COMPANY
170 Falstrom Court, Passaic, New Jersey
PRescott 7-0013
Write in No. 35 on Reader Service Card

Chemical Composition of Materials Studied
(per cent by weight)

Steel	C	Mn	Si	Cr	Ni	Mo
SAE 4340	0.44	0.67	0.27	0.77	1.74	0.20
Tool steel #1	0.63	0.60	0.21	0.70	1.20	0.16
Tool steel #2	0.88	1.51	0.28	. . .	. . .	0.25
SAE 52100	1.06	0.34	0.19	1.38	. . .	. . .

NBS has tried to resolve the problem by a detailed study (conducted in cooperation with the University of Maryland). Its goal was to find out how controlled variables (carbon content, tempering temperature, cooling method for hardening, refrigeration) and dependent variables (retained austenite, hardness, etc.) are related to fatigue strength.

Preliminary experiments, NBS states, indicated that the usual method of preparing fatigue specimens can often mask surface metallurgical effects that may be of prime importance. A new method was therefore devised and used for all the test specimens.

Four low alloy steels were tested

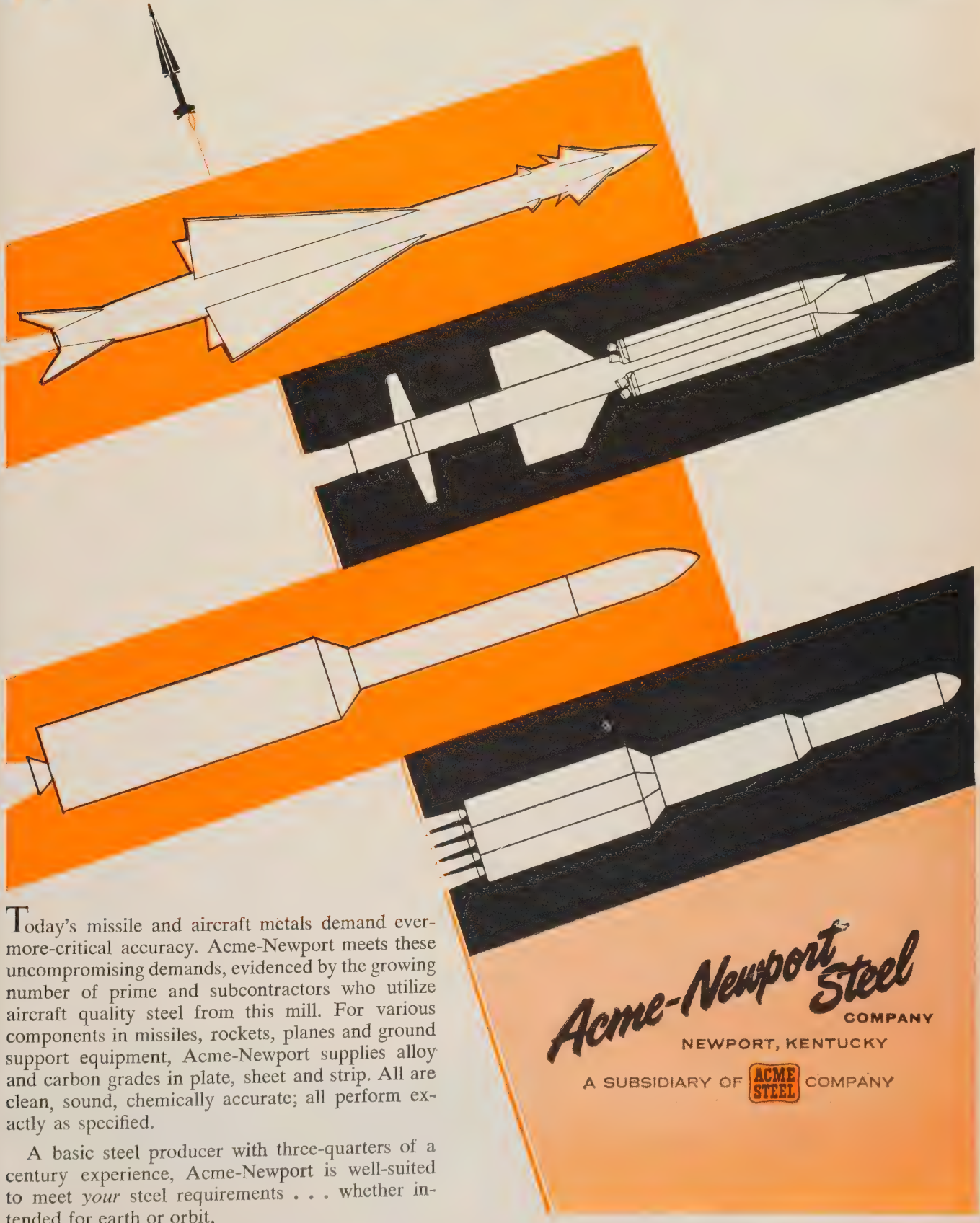
The materials selected for the program were four low alloy steels whose carbon contents ranged from 0.44 to 1.06 per cent. Blanks of these steels were ground, given a final polish, and then copper-plated before heat treatment. After heat treatment and stripping of the protective coating, no further polishing

more on page 88

THE TREND
IN DRAFTING ROOMS
THROUGHOUT
THE WORLD IS
TOWARD IMPERIAL,
THE WORLD'S FINEST
TRACING CLOTH
Write in No. 36 on Reader Service Card

Acme-Newport

AIRCRAFT QUALITY STEEL
for PERFORMANCE THAT'S OUT OF THIS WORLD



Today's missile and aircraft metals demand ever-more-critical accuracy. Acme-Newport meets these uncompromising demands, evidenced by the growing number of prime and subcontractors who utilize aircraft quality steel from this mill. For various components in missiles, rockets, planes and ground support equipment, Acme-Newport supplies alloy and carbon grades in plate, sheet and strip. All are clean, sound, chemically accurate; all perform exactly as specified.

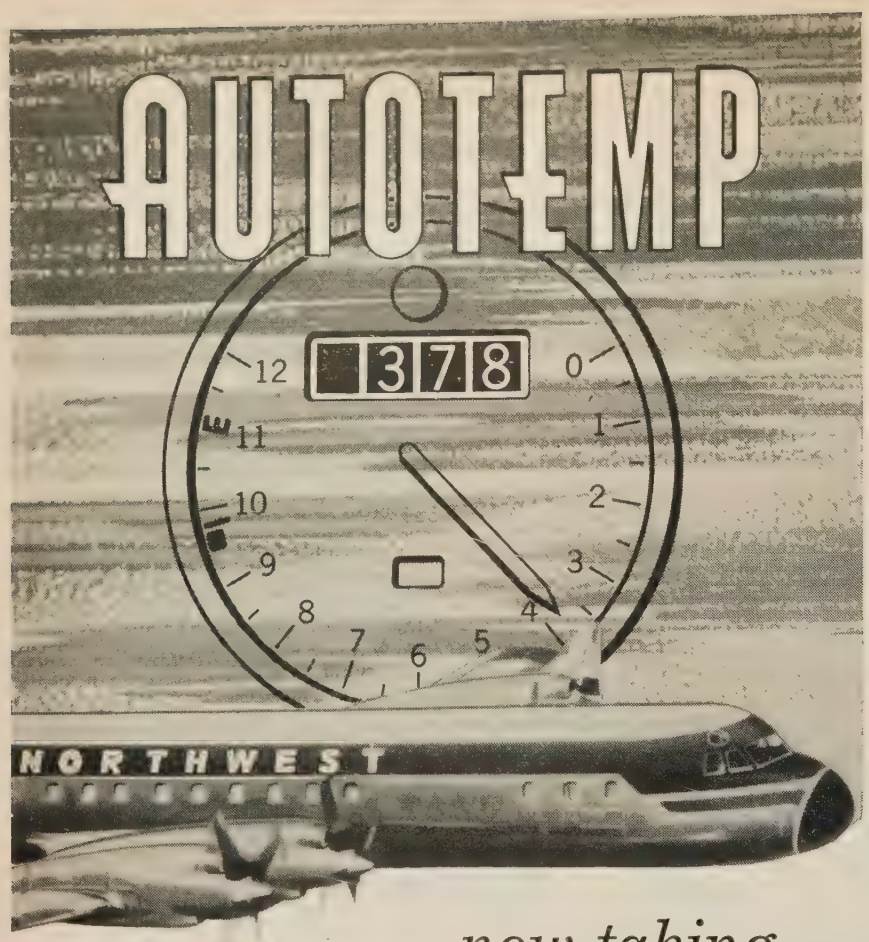
A basic steel producer with three-quarters of a century experience, Acme-Newport is well-suited to meet *your* steel requirements . . . whether intended for earth or orbit.

Acme-Newport Steel COMPANY

NEWPORT, KENTUCKY

A SUBSIDIARY OF ACME STEEL COMPANY

Write in No. 37 on Reader Service Card at start of Product Preview Section



...now taking Lockheed ELECTRA'S *temperature...to 1°C.*

High accuracy, and easiest *needle pointer plus digital in-line counter readout,* are the principal service features of the BH183 AUTOTEMP® jet engine temperature indicator.

AUTOTEMP is designed and produced by the makers of the JETCAL Analyzer®, the only jet engine tester used throughout the world.

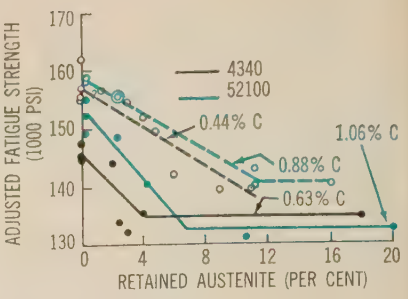
The AUTOTEMP is a completely new instrument...a continuous null balance 144-inch slidewire potentiometer combined with a linearizing analog-to-digital converter. Its accuracy is the simple attribute or phenomenon of its novel and basic slidewire potentiometer!

Completely self-contained...transistorized, miniaturized, hermetically sealed, servo-driven...the AUTOTEMP'S 3"-diameter case includes a Zener reference, power supply, amplifier, servo motor, cold junction compensation and the 144-inch slidewire and punched tape to linearize thermocouple e.m.f. for exact, counter-type digital readout. The needle pointer indicates in 50°C increments over the 0 to 1200°C full range of the unit.

Full information is contained in our Bulletin BH183 available for the asking!

B & H INSTRUMENT CO., INC.
3479 West Vickery Blvd. • Fort Worth 7, Texas
Sales-Engineering Offices: COMPTON, CAL., VALLEY STREAM, L.I., N.Y., DAYTON, OHIO

Write in No. 38 on Reader Service Card at start of Product Preview Section



ADJUSTED fatigue strength (to 10^5 cycles) shows effect of retained austenite. As retained austenite increases, fatigue strength decreases.

was needed. The resulting specimens, researchers say, were free from surface changes due to mechanical working.

Stress amplitude was used as a measure

Before testing started, the basic assumption was made by H. E. Frankel and J. A. Bennett of NBS and W. A. Pennington of the University that alloying elements (excluding carbon) had less effect on fatigue strength than the steel micro-structure. An experimental plan was also devised to permit studies of a number of variables with a reasonable number of specimens. It called for using only about a fourth of all possible combinations of material, quenching procedure, and tempering procedure and temperature.

For satisfactory analysis of such an experiment, the test results for each condition must be expressed by a single number. In this case, the stress amplitude that caused failure in 10^5 cycles was used as a measure of fatigue strength.

A strong correlation was found between fatigue strength and hardness. Therefore data for each steel were adjusted to an average hardness before the effects of other variables were evaluated.

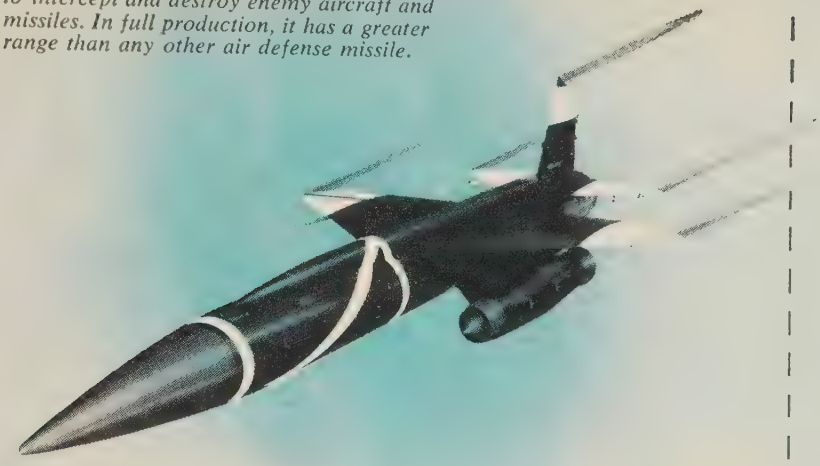
Test runs lasted up to complete fracture

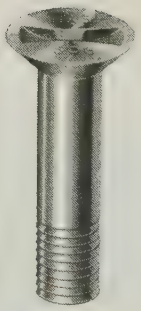
Tests were run on Moore-type rotating beam fatigue test machines at a top speed of 8000 rpm. The machines operated until complete fracture occurred.

The *Graphs* show some of the

more on page 90

THE BOEING IM-99 BOMARC . . . *is a long range, extremely high altitude supersonic missile designed to intercept and destroy enemy aircraft and missiles. In full production, it has a greater range than any other air defense missile.*





HI-TORQUE BOLT

IDEAL FOR FASTENING STRESSED ACCESS AND CLOSE-OUT PANELS. ITS UNIQUE SHALLOW RECESS LOCKS THE DRIVER INTO IT WHEN A HIGH TORQUE LOAD IS APPLIED DURING INSTALLATION OR REMOVAL.

STRUCTURAL EFFICIENCY CONTRIBUTES TO GREATER PERFORMANCE

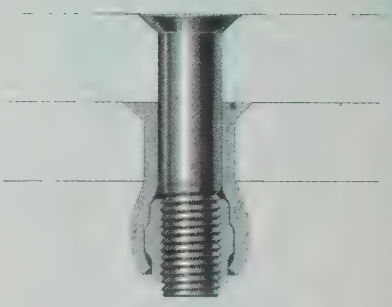
The airframe of the Bomarc reflects a successful solution to structural and fastening design problems typical to high performance missiles and aircraft. The airframe combines high strength with high temperature resistance, without adding unnecessary weight which could effect performance.

Three different fastener problems in the Bomarc are solved by stainless steel Hi-Shear fasteners. Hi-Shear Rivets are used in structure subjected to engine and rocket boost heat . . . Hi-Torque Bolts fasten removable panels and the nose section where heat, surface smoothness and ease of removal are factors. Blind Nuts eliminate hole/nut coordination problems in congested areas.

Continuing fastener environmental studies are being conducted at the Hi-Shear Test and Research Laboratories in a variety of strength and temperature resistant material combinations for advanced structural requirements.

HI-SHEAR RIVET

HAS THE LIGHTEST STRENGTH-WEIGHT RATIO, LEAST PROTRUSION AND LOWEST COST OF ANY SWAGED TYPE FASTENER. INSTALLED WITH STANDARD RIVET GUNS OR SQUEEZERS FITTED WITH HI-SHEAR RIVETING SETS.



BLIND NUT

FOR BLIND OR OPEN APPLICATIONS, THE BLIND NUT CUTS PRODUCTION COSTS BY USING ONE HOLE INSTEAD OF THE NORMAL THREE REQUIRED FOR NUTPLATES. INSTALLATION SPEED IS ABOUT TEN PER MINUTE BY ONE MAN USING A LIGHTWEIGHT, HYDRAULICALLY OPERATED GUN.

U.S. PATENT PENDING, FOREIGN PATENTS GRANTED AND PENDING

HI-TORQUE ' TRADEMARK REGISTERED IN U.S. PATENT OFFICE
U.S. PATENTS NO. 2,677,985; 2,745,120 AND 2,792,039
U.S. PATENT PENDING

HI-SHEAR'' TRADEMARK REGISTERED IN U.S. PATENT OFFICE
U.S. PATENTS NO. 2,355,879, 2,355,580; D-138-579,
OTHER U.S. AND FOREIGN PATENTS PENDING.

Hi-Shear RIVET TOOL COMPANY

2600 WEST 247TH STREET, TORRANCE • CALIFORNIA

Write in No. 39 on Reader Service Card at start of Product Preview Section

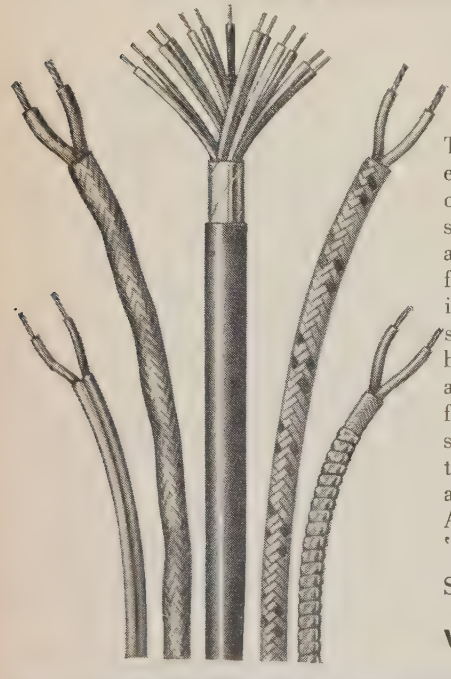
Playback on performance

Autonetic's NADAR increases flight training efficiency by making a magnetic-tape recording of everything an airplane's fire control system puts on the radar scope. Minutes after pilot lands, complete record of his performance can be viewed on oscilloscope of NADAR console. Compact, lightweight, airborne tape-recorder (shown above in officer's hand) is fully automatic, has two-hour recording capacity. NADAR is invaluable for pilot and aircrew evaluation and flight testing . . . and remember, military pilots are *always* training. Write for literature.

Autonetics

A DIVISION OF NORTH AMERICAN AVIATION, INC., DOWNEY, CALIFORNIA

Choose From The Widest Variety Of Thermocouple Wires



Over 1500 Different Types

T-E's tremendous variety of thermocouple extension wires assures you quick delivery of every type and size—from one reliable source. Dependable quality control is also assured by T-E's own complete facilities for wire drawing, insulating and calibrating. T-E duplex wires come in solid or stranded construction, in all standard calibrations. The latest types of insulation and metallic armor overbraid protect them from all atmospheric, chemical and abrasive conditions. From 6 to 56 pairs of T-E thermocouple leads can now be installed at one time with the new "Thermo-Cable". Also available—a complete selection of "MIL"- Spec Wire.

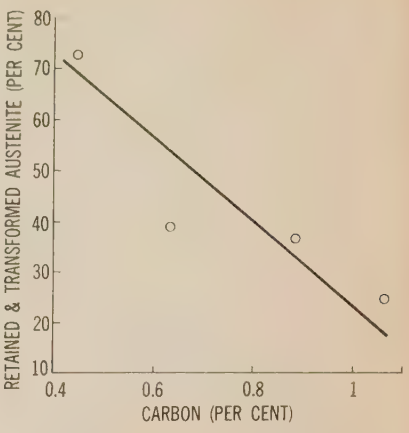
See Our Full Line—

Write for Wire Bulletin 32WS-A

Thermo Electric CO., INC.
SADDLE BROOK, NEW JERSEY

In Canada:
THERMO ELECTRIC (Canada) LTD.,
Brampton, Ont.

Write in No. 40 on Reader Service Card at start of Product Preview Section



NBS data show decrease in austenite transformation at equal amounts of stress as the carbon level of steel specimens is increased.

results of the tests. The consistency of results for four steels of different alloy content, it was concluded, confirmed the assumption that microstructure has more effect on fatigue than does alloy content.

The data also indicates that, as carbon content increases, a higher hardness is needed for equivalent fatigue strengths. Contrary to the findings of previous researchers, Frankel, Bennett, and Pennington report no significant difference in fatigue strength caused by interrupted quench.

Retained austenite cut fatigue strength

Tests results show that the adjusted fatigue strengths of all four steels decreased as the amount of retained austenite (determined by X-ray diffraction analysis) increased. For the three higher-carbon steels, though, there seemed to be a limiting value of about 10 per cent beyond which no further decrease in strength resulted.

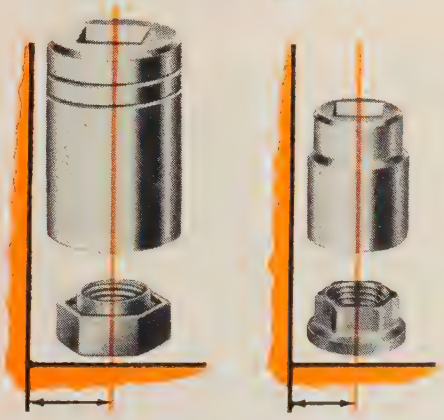
Specimens refrigerated before tempering had greater fatigue strengths than unrefrigerated ones. This, scientists believe, indicates refrigeration tends to reduce the amount of retained austenite.

The test also showed that fatigue stressing transforms retained austenite to untempered martensite. Measurements on tested blanks also showed that the extent of this transformation depends on the stress amplitude. It was concluded that this transformation might account for the harmful effect of the retained austenite.—**IS**

NEW KAYLOCK H14!

First 160,000 PSI LOW HEIGHT Locknut

COMPARE WRENCH ACCESS
Standard Hex vs New H14



See how new Kaylock H14

- **Saves weight and space**
- **Brings bolt closer to load center line**
- **Permits narrower flanges**

It's another pace-setting development by Kaynar, who pioneered the first lightweight, self-locking nuts for airframes, missiles, jet engines and electronics.

The new Kaylock H14 offers these exclusive advantages:

- 20% to 62% lighter than Kaynar's original H10 hex nut series—smaller envelope dimension
- Tensile strength rated for 160,000 PSI bolts
- Uses two-size smaller sockets than for Standard AN and NAS nuts
- Nut and bolt can be moved closer to load center line
- Patented* Kaynar thin-wall, resilient self-locking device assures uniform locking torque

*Pat. No. 2,816,591 — Other Patents Pending.

KAYNAR MFG. CO., INC.— DEPT. SA759
Box 2001, Terminal Annex, Los Angeles 54, Calif.

Please send me a copy of your H14 Brochure.

*Name*_____ *Title*_____

*Company*_____

*Company address*_____

*Home address*_____

*City*_____ *Zone*___ *State*_____

Get ALL the facts about the new Kaylock H14. Fill in and mail coupon now!

KAYLOCK®
All-Metal Self-Locking Nuts

KAYNAR MFG. CO., INC. — KAYLOCK DIVISION
Home office and plant: Write Box 2001, Terminal Annex, Los Angeles 54, Calif. Branch offices, warehouses and representatives in Wichita, Kansas; New York, N.Y.; Atlanta, Georgia. Canadian Distributor: Abercorn Aero, Ltd., Montreal, Quebec.

©Kaynar Mfg. Co., Inc., 1959

Write in No. 41 on Reader Service Card at start of Product Preview Section

SIKORSKY says AMP®

The electrical harness being assembled in the upper right photograph is part of the new Sikorsky S-62 helicopter. Through this "central nervous system," the pilot operates all electrical/electronic components of the aircraft. And, dozens of A-MP terminal products are used to terminate and connect this vital "central nervous system."

There are several good reasons why A-MP terminal products are used in the "central nervous system" of today's aircraft: engineers remark *reliability;* plant superintendents note economy—*in both time and money;* assembly line employees say *easy installation;* and inspectors add *no rejects.*

A-MP products will meet your exacting circuitry requirements and save you money on total installed costs.

Write for more information on the unbeatable reliability and economy of our circuitry termination method.

AMP INCORPORATED

GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

A-MP products and engineering assistance are available through subsidiary companies in: Canada • England • France • Holland • Japan

Write in No. 42 on Reader Service Card at start of Product Preview Section

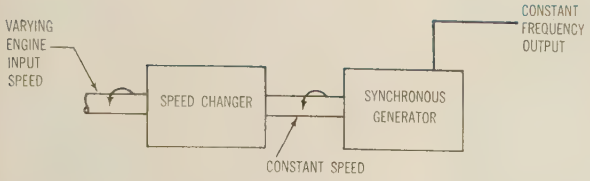


FIGURE 1: Changing engine speed is converted to a constant value by a speed changer to give a synchronous generator a constant output frequency.

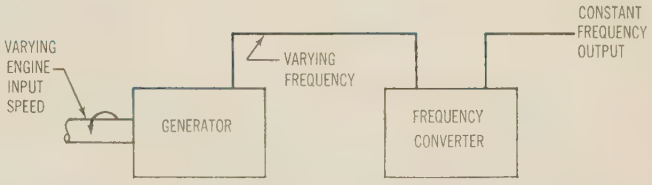


FIGURE 2: A frequency converter is used to convert the varying-frequency power of a conventional generator operating at varying speed.

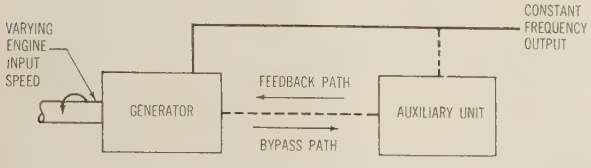


FIGURE 3: Varying generator frequency is converted by feedback from the output lines.

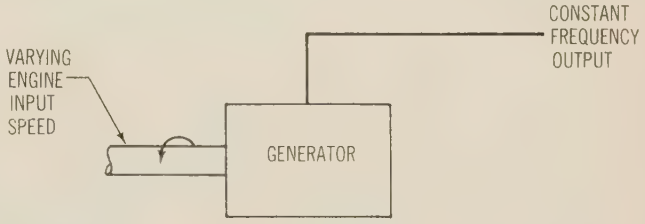


FIGURE 4: Constant-frequency output is obtained directly from a generator running at varying speed.

Six rules for evaluating CFVS generators

In a recent GE development program, more than 30 constant-frequency, varying-speed (CFVS) generators for airborne use were analyzed—a wide field of choice. To find your way around in it, use this review of the basic principles that must be applied in any CFVS generator evaluation.

by F. T. DeWolf, E. A. Erdely, E. E. Kolatorowicz and W. R. Miller,
DC Motor & Generator Dept., General Electric Co.*

IN MOST applications of constant-frequency electric power, a hydraulic drive serves as a speed changer between the engine and generator, converting the changing engine speed to a constant value *(Fig. 1)*. The same job could be done by pneumatic or friction drives or even by electromagnetic devices. Among these last, perhaps the simplest is the eddy-current clutch in which the output speed is maintained constant by controlling the slip in the electric clutch. More complicated packages might involve several machines.

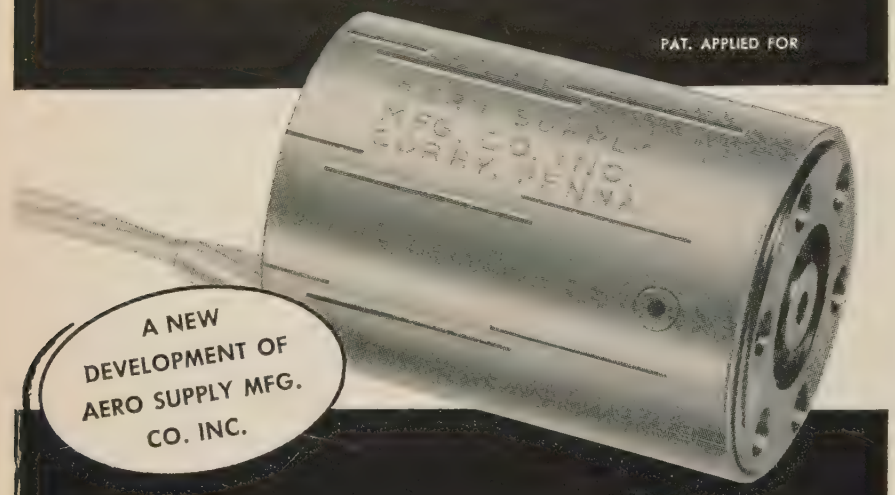
In *Figure 2*, varying-frequency electric power — such as produced by a conventional generator operating at varying speed — is passed through a frequency-converter box for conversion to a constant frequency. Again, the conversion equipment may consist

* DC Motor & Generator Dept., General Electric Co., Erie, Pa.

more on next page

400 CYCLE
NON-RECTIFIED
AC SOLENOID VALVE

PAT. APPLIED FOR



A NEW DEVELOPMENT OF AERO SUPPLY MFG. CO. INC.

SHOWN TWICE ACTUAL SIZE

AERO SUPPLY ACCEPTED A CHALLENGE THAT 92 OTHER MANUFACTURERS TURNED DOWN . . . THE CREATION OF A DIRECT ACTING 400 CYCLE NON-RECTIFIED AC SOLENOID VALVE FOR A MOST UNUSUAL APPLICATION INVOLVING WEIGHT REDUCTION AND RELIABILITY.

Aero Supply has designed and built a 400 cycle non-rectified AC solenoid valve for precision high temperature operation or for immersion in JP-6 fuel. While this valve is designed for one specific application, Aero Supply has established capability in this area and is prepared to design and manufacture other 400 cycle non-rectified solenoids/valves to meet your specification. Request Bulletin #59-130 and our Capabilities Report.

ENGINEERS WANTED . . . If you would like to join a growing dynamic creative organization, send your resume to our Chief Engineer.

AERO SUPPLY MFG. CO. INC.
CORRY, PENNSYLVANIA
ELECTRO-MECHANICAL DEVICES • ENGINEERED FLUID CONTROL SYSTEMS • PRECISION MANUFACTURING

Write in No. 43 on Reader Service Card at start of Product Preview Section

of more than one unit. It may even be an electronic device using tubes or semiconductors.

In *Figure 3*, power is fed back from the output lines to modify the generator frequency. The feedback unit may be a static assembly, or it may be a second machine. Power can be returned to the generator either electrically or mechanically (e.g., by a fixed-ratio, three-element gear system).

In *Figure 4*, a constant frequency output is obtained directly from a generator running at varying speed. Induction generator systems, many commutator-type machines, and systems using other forms of switching, follow this principle.

More than 30 CFVS generator schemes have been analysed in the course of a GE development program. Six basic principles have been applied in the evaluation of these generators for airborne use.

"Slip" schemes for small speed changes

We can separate those systems that inherently waste "slip" power from those that theoretically are 100 per cent efficient in this respect. The eddy-current clutch, a simple "slip" scheme, is very effective for small variations of engine speed. If engine speed varies by more than 30 per cent, however, this clutch becomes less efficient than the hydraulic drives now used.

The trouble is that a slipping clutch, whether mechanical or electrical, is basically inefficient. The speed of the driven member is reduced by throwing away power in proportion to the amount of speed reduction. So we come to our first rule:

• *The efficiency of a "slip" device is basically limited, since energy must be destroyed in proportion to the amount of slip.*

This inherent inefficiency is far from obvious in more involved schemes. The induction generator for instance, has several advantages for aircraft applications. These are overshadowed, however, by the drawback of limited efficiency. An induction generator is essentially an induction motor driven above the synchronous speed of the rotating field in the air gap. energy must be dissipated in proportion to slip, just as in the case of speed control with wound-rotor induction motors.

more on page 96

FIRST RULE
FOR
DELEGATING
GROUND
SUPPORT
EQUIPMENT
RESPONSIBILITY:

FIND AN AUTHORITY

Through 70 years of war and peace, St. Louis Car has developed, tested and built transport and handling equipment . . . railroad stock . . . amphibious vehicles . . . aircraft . . . special-purpose carriers and mounts.

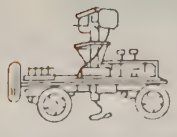
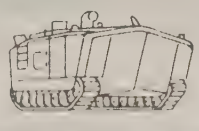
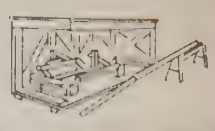
Use this experience when you need transport and handling equipment, engineered from the systems approach to meet the specific operational objectives of your weapon.

Before you assign any transport and handling equipment work—from R&D to production—evaluate St. Louis Car. We welcome the chance to submit proposals.

ST. LOUIS CAR COMPANY

St. Louis 15, Mo.

Write on your letterhead for Information Kit SA-11.

Write in No. 44 on Reader Service Card at start of Product Preview Section

Because of the heat dissipation problem at high slips, induction generators are limited to moderate slips. Another serious limitation is posed by the need for a reactive current source.

Slip losses are greatest at high engine speed, when the aircraft cruises for extended periods and efficient operation can be had only during idling. If a gear is provided between the drive shaft and the clutch, efficient operation at two speeds becomes possible.

A problem comparable to the efficiency limitation of induction generators has been solved by a spherical adjustable-speed induction motor developed in Britain. Tests have shown that this machine fundamentally can operate efficiently over wide speed range as a motor— and as an induction generator as well.

The relatively high efficiency of this spherical machine doesn't, as it would first seem, upset the general rule we have formulated. In this design, the slip remains small as the speed is changed, and so efficiency is relatively high. The trick is done by varying the circumferential component of the rotational speed of the air-gap field with a stator made up of discrete portions of blocks that can be twisted or turned mechanically. This design and other similar ones, however, are not without their disadvantages, especially for airborne use.

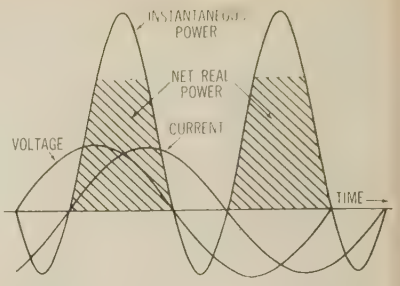


FIGURE 5: Current and voltage vs time for a synchronous generator supplying reactive current. Instantaneous power reverses direction even though the average, or net real power, remains positive.

In comparing the size and weight of electromagnetic equipment driven at varying speed with the values for equipment driven at constant speed, we must remember that the size of a generator is determined by the torque it must absorb. The mechanical power input to a generator is a product of the input speed and torque. Therefore, the generator must be bigger if it is to develop the same power at a lower speed, since is must absorb more torque.

Today's aircraft generators are very compact and light. The high speed at which they operate contributes to their small size. If they had to generate full power over a wide speed range with a minimum speed lower than present ones, larger machines would be needed. This leads to our second rule:

• *A varying-speed generator basically can be expected to be larger and heavier than a constant-speed unit if it must operate with the same output at a lower speed.*

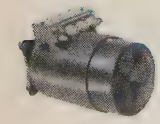
To accomodate both engine idling and cruising speeds, a gear change could be added to limit generator size. Steels with higher flux capacity, lower resistance conduc-

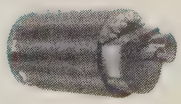
more on page 98

BREEZE is
Years ahead in...
STARTER GENERATORS

VG 460 • 30 VOLTS
75 AMPERES

VG 600 • 30 VOLTS
100 AMPERES


VG 840 • 30 VOLTS
100 AMPERES
HIGH SPEED


VG 1000 • 30 VOLTS
200 AMPERES

Ten solid years of design, development and manufacture have given Breeze unmatched experience in solving the problems of special starter generator equipment. Our equipment is designed to high performance needs in critical applications . . . with special emphasis on SMALL GAS TURBINE ENGINES. It has been tested and proved in trainer aircraft, target drones, helicopters and related ground support equipment. Our engineers know this subject *thoroughly*. Our experience in this field has no equal.

Write for technical data.

BREEZE
BREEZE MARK
CORPORATIONS INC.
700 LIBERTY AVENUE • UNION, N. J.

BREEZE PRODUCTS: ACTUATORS • HOISTS • TRANSMISSIONS • GENERATORS • STARTERS
STARTER GENERATORS • BELLOWS • SLIP RINGS • HOSE CLAMPS • HITEMP FLEXIBLE TUBING

Write in No. 45 on Reader Service Card at start of Product Preview Section

move it in . . . couple it . . . turn it on . . .

with a VICKERS® "packaged" unit power is instantly available to operate your missile-support system

Fast and easy installation is an important advantage of these "packaged" hydraulic power and control systems by Vickers. It saves time at the missile site — keeps "on-the-spot" labor charges low. That's important! Yet this fast installation is only one of the benefits you get with these factory-built power packages.

Save Design Time — Since 1932 Vickers has custom designed hydraulic power packages. Thus, we know how to avoid "false starts" and can develop highly efficient units *in a hurry.*

Eliminate Mismatching — Each power package contains compatible, balanced components all produced by Vickers. There are no hybrids — there is no need for "force fits".

Save Space — Units are surprisingly compact, yet all components are easily accessible. Solid steel drilled manifolds reduce piping and space. Components, lines and connections are kept to an absolute minimum.

Simple Field Adjustment — The building-block concept is followed to give component interchangeability, servicing ease and quick location of any malfunction. All components are individually tested; complete power units are pretested before shipment.

Insure Predictability — Vickers designs and builds systems which meet the most rigid performance specifications including predicted ambient temperature, weather and other conditions.

Reduce Field Inventory — As far as possible, units are designed with components that are commercial "shelf" items. Inventories of warehouse stocks can be kept low because of component and part interchangeability.

How far advanced is your project? If it is in the design and development stage, we can *immediately* place a team of hydraulic specialists in your plant to work with your engineers. If it is in the "breadboard" stage, let us give you an alternate proposal. On many applications we have suggested much improved power units at attractive production-line prices.

Write for Bulletin 5303
"Vickers Oil Hydraulics for Missile Systems"

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
Marine and Ordnance Department
WATERBURY 20, CONNECTICUT

Hydraulic Products for Marine and Ground Defense Applications

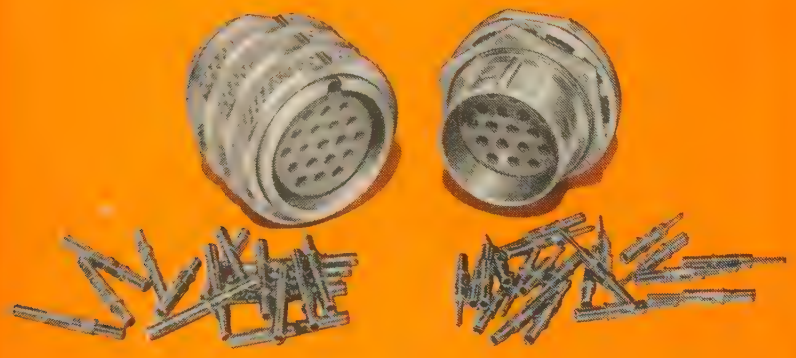
MO-215B

DISTRICT SALES OFFICES: DETROIT, MICH. • EL SEGUNDO, CALIF. • MEDIA, PA. • SEATTLE, WASH. • WASHINGTON, D. C.

Write in No. 46 on Reader Service Card at start of Product Preview Section

New Deutsch "Snap-In" Miniature Connectors

make RELIABILITY a REALITY



Here's a snap-in miniature you can trust to do what it's supposed to do. The new Deutsch DS Series of quick-disconnect connectors—with insertable and removable contacts and crimp-type terminations—has been thoroughly tested and *proved* under extreme environmental conditions.

proven

Check these advantages

against your design requirements

		DS FEATURES	YOUR DESIGN REQUIREMENTS
1	Pins and sockets	Easily insertable and removable	
2	Terminations	Crimp-type	
3	Contact retention	Withstands minimum of 25 lbs. pull	
4	Crimp strength	Greater than the wire itself	
5	Hand tools	Simple, fool-proof crimping, inserting and removal tools	
6	Interfacial seal	Continuous dielectric separation without voids; no bonding, reversion or shrinkage of inserts	
7	Environmental	Meets or exceeds MIL-C-26482 (ASG)	
8	Temperature	—100°F. to 300°F.	
9	Push-pull coupling	Positive ball-lock design; operates in direction of plug travel	
10	Contact size	Immediately available in #20 size; others to follow	
11	Shell size	Immediately available in 3, 7, 12, 19, 27, 37 and 61 contacts	
12	Interchangeability	Mates with existing Deutsch DM5000, DM6500 and DM9000 series	
13	Assembly	Delivered completely assembled except for insertion of contacts	

For complete technical information and test report, contact your Deutsch Representative or write us for Data File E7.

The Deutsch Company

7000 Avalon Boulevard • Los Angeles 3, Calif.

© THE DEUTSCH COMPANY, 1959

Write in No. 47 on Reader Service Card at start of Product Preview Section

tors, insulation systems and bearings suitable for higher temperature, more effective heat removal, and radically different designs also would help to hold down size. Furthermore, the size increase can be minimized if the higher speeds are above the normally used speeds, so that the lower speeds are high as possible.

Rotational stresses limit size reduction

Size reduction through higher operating speeds, however, is limited by the acceptable rotational stresses. Since it is the relative speed between rotor and stator that determines machine size, contrarotation may be used to advantage. Increases in the relative speed between rotor and stator reduce the torque needed to transmit a given power and makes possible a corresponding size reduction. So we come to our third rule:

• *The electromagnetic weight of generators can be reduced by contrarotation.*

The idea of a machine with two members free to turn suggests a simple method of getting constant frequency: A constant frequency will result if the "stator" of a synchronous generator is driven separately to maintain a constant speed differential with respect to the rotor, which is driven by the varying-speed engine. Current collection from the rotating outer member is troublesome, of course. Also, the driving device must oppose the full torque of the generator. Therefore, the power needed to drive the "stator" is on the same order of magnitude as the rotor input power if the speeds are comparable.

The relative speed between stator windings and rotor flux may be kept constant—regardless of variations in rotational speed—by supplying ac to a suitably wound rotor. Constant-frequency power can be produced by a generator provided with a distributed polyphase field winding excited from variable frequency power, so that the magnetic field turns at a constant speed, regardless of the physical speed of rotation. We now have our fourth rule:

• *In varying-speed generators in which the speed of the generator field flux is kept constant with respect to the armature windings, a*

more on page 102

SCOTCH BRAND
SCOTCH BRAND
SCOTCH BRAND
SCOTCH BRAND
SCOTCH BRAND
SCOTCH BRAND
SCOTCH BRAND
SCOTCH BRAND
SCOTCH BRAND
SCOTCH BRAND
SCOTCH BRAND
SCOTCH® BRAND
SCOTCH BRAND

TAPEnology provides new tool for preserving space age weapons

A remarkable new pressure-sensitive tape—"SCOTCH" Brand Plastic Tape No. 481—now makes positive preservation sealing of openings in idle aircraft, missiles and other vital standby equipment a reality. It sticks at a touch . . . provides all-weather protection almost indefinitely . . . yet removes in a jiffy.

This new member of the "SCOTCH" Brand Tape family conforms to irregular surfaces easily . . . provides a good moisture-vapor barrier . . . is flexible over a temperature range from –60°F. to +160°F. . . . is inert to most common fuels, lubricants, oils, solvents . . . resists shrinkage even under extreme outdoor exposure. Special adhesive sticks to any clean, dry surface at below freezing temperatures . . . resists staining . . . removes cleanly without adhesive transfer.

What do you want preserved? Chances are, this new "SCOTCH" Brand Plastic Tape will offer you important advantages in protection, cost, and application utility. Ask your nearest "SCOTCH" Brand Tape Distributor for more information, or write: 3M Co., 900 Bush Ave., St. Paul 6, Minn., Dept. 1AO-79.

When tape costs so little, why take less than "SCOTCH" Brand?

"SCOTCH" is a registered trademark for the pressure-sensitive adhesive tapes of 3M Co., St. Paul 6, Minn. Export: 99 Park Ave., New York 16. Canada: London, Ontario.

MINNESOTA MINING AND MANUFACTURING COMPANY
. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

Write in No. 48 on Reader Service Card at start of Product Preview Section

NEW TITANIUM ALLOYS, IMPROVED PROPERTIES FOR

Several new titanium alloys may prove to be the answer to designers' needs for improved tensile and fatigue strength, ductility and corrosion resistance in aircraft and spacecraft materials.

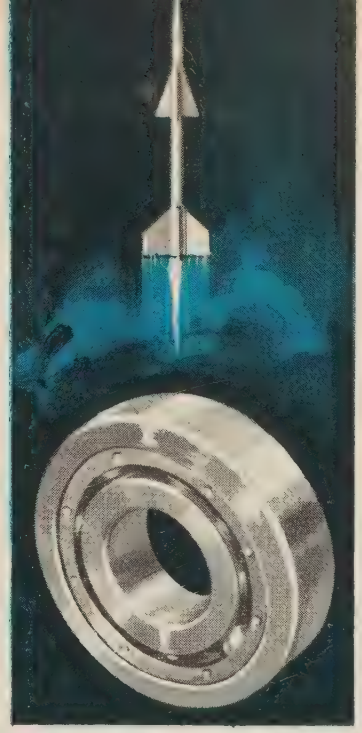
One of the alloys is Crucible B-120VCA. This new, weldable alloy has the highest strength/weight values of any structural material available. At 220,000 psi, its strength/weight ratio is equivalent to that of steel at 360,000 psi. And it maintains its strength/weight advantage for short times at temperatures up to 1400° F. Furthermore, B-120VCA is "Formageable"® (readily formed in the "soft" solution annealed condition and then strengthened by age-hardening).

As this is written, about 50 aircraft and missile manufacturers are testing Crucible B-120VCA samples. They're reporting: (1) it's easier to fabricate than any other titanium alloy; (2) it seems ideal for rocket motor cases, structural members, rivets and other components.

Several other critical design problems are being solved by Crucible vacuum melted steels and superalloys. Some Crucible alloy and tool steels, for example, possess tensile strengths in the 280,000-300,000 psi range and even higher. Up to now, getting uniform transverse ductility at this strength level has been a problem. Crucible solved it through vacuum melting.

These developments are typical of Crucible advances in specialty steelmak

b.



c.

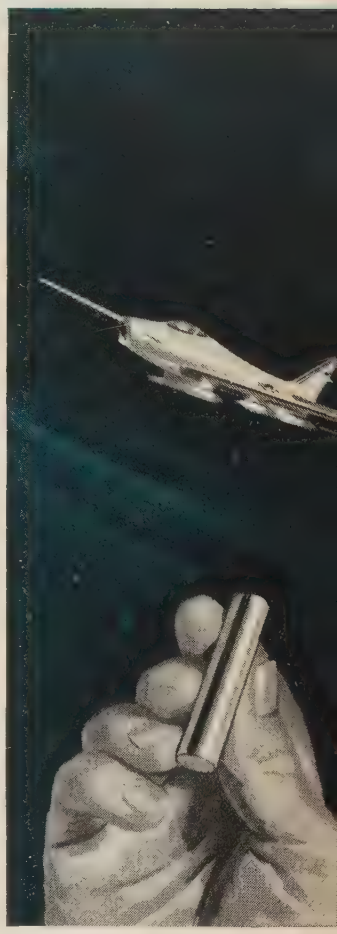
a. Lowering a consumable electrode into a vacuum arc furnace. Metals produced by vacuum melting are "cleaner" and therefore offer improved strength, ductility and longer fatigue life.

***b. Titanium,** more than 1000 lbs. of it, saves 800 lbs. in Convair 880 because of metal's high strength/weight ratio. Principal use is in jet engine pods, aileron, stabilizer, and tail assembly.*

***c. Crucible Vacuum-Melted Bearing Steel** makes stronger, longer-lasting bearings. Rejects during manufacture and early failures are virtually eliminated.*

***d. Vacuum-Melted 4340** was specified for hook pivot pin of bomb rack and rocket launcher when air melted steels failed to withstand 4½ hour destructive vibration tests.*

d.



IIGH PURITY METALS PROVIDE MISSILE DESIGNERS

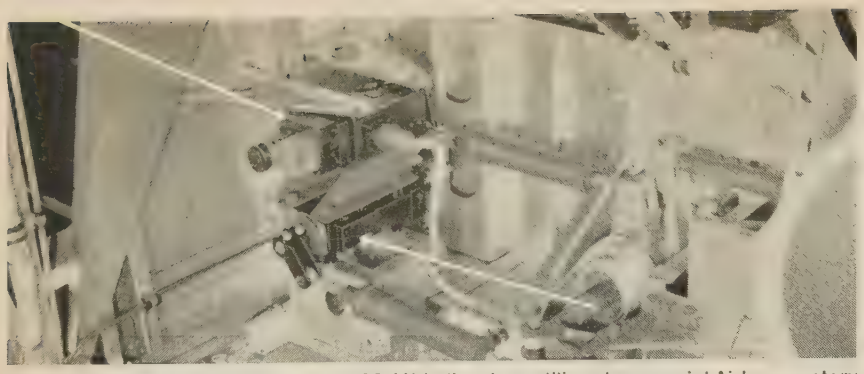
. They're possible because Crucible is mpletely integrated—and because ucible pioneered in the development titanium, the high temperature alloys, l in vacuum induction melting and uum arc remelting techniques.

Today, Crucible's experience—and newly-increased capacity for vacuum arc remelting of its own special air melted and vacuum induction melted electrodes—provides industry with a complete range of High Purity Metals at lowest cost.

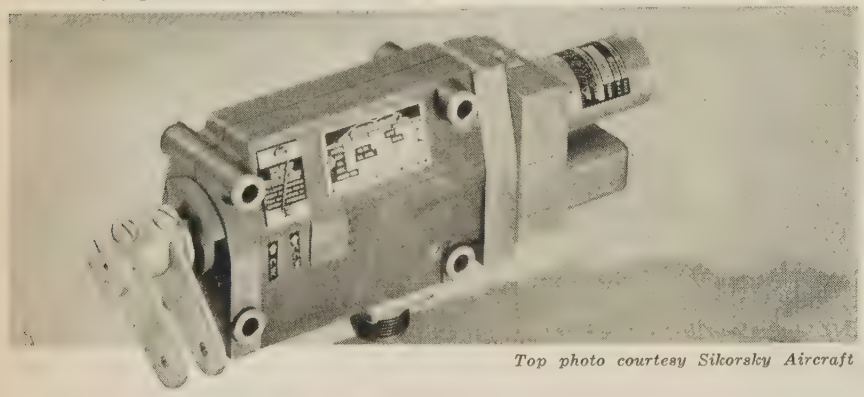
If you'd like to know more about this work, read: "Titanium for Aircraft and Spacecraft" and "Quality Aspects and Engineering Properties of Vacuum Melted Super Alloys and Steels". Write: *Crucible Steel Company of America, Dept. AG18, The Oliver Bldg., Mellon Square, Pittsburgh 22, Pa.*

CRUCIBLE STEEL COMPANY OF AMERICA

Write in No. 49 on Reader Service Card at start of Product Preview Section



Trim system of Sikorsky HUS-1 and HSS-1N helicopters utilizes two special Airborne rotary actuators, acting through force gradient springs, to position and hold cyclic sticks. Pilot can override springs to maneuver; then have stick return automatically to trimmed position.



Top photo courtesy Sikorsky Aircraft

Airborne special actuators provide helicopter trim control

One of the more recent applications of Airborne special design actuators is found on Sikorsky's HUS-1 and HSS-1N helicopters. Two Airborne R4610 TRIM TROL units are used on these aircraft as moveable anchor points for a force gradient system of trim control. The system is an ingenious one, offering the pilot several control options.

For example, to make a quick maneuver, he can override the force gradient springs manually, without disengaging the actuator clutches. When released, the stick then returns automatically to original position. Alternatively, he can disengage the clutches by pushing the stick trim button, thus removing the force gradient system from the controls while maneuvering to a new flight condition. In this instance, the stick remains spring centered in the new position when the button is released.

A third control option permits changing flight attitude by power. Using a "beeper" button, the pilot energizes the actuators to drive the stick slowly to a new trim position, where it remains centered when the button is released. Finally, the system can be disconnected entirely, leaving the stick free and without artificial feel.

A detailed description of this system and the actuators employed is contained in new Airborne Bulletin PS-3A, available on request.

AIRBORNE®

Engineered Equipment for Aircraft and Industry

AIRBORNE ACCESSORIES CORPORATION

HILLSIDE 5, NEW JERSEY • Offices in Los Angeles and Dallas

Write in No. 80 on Reader Service Card at start of Product Preview Section

substantial mechanical or electrical power input (which depends on input speed variation) is needed under load in addition to the shaft power input.

In a machine with electromagnetic field rotation, the "field winding" therefore is more than a flux-producing winding. It produces or consumes power in proportions comparable with the main power winding. For example, for a generator to develop 60 kw when driven at half synchronous speed, the ac "field excitation" needed for synchronous rotation of the field flux at full load is 30 kw. If this power is taken from the output, then there remains only 30 kw as usable power, assuming 100 per cent efficiency throughout.

The power feedback systems using mechanical contrarotation and electromagnetic field rotation belong to the large variety of systems shown generally in *Figure 3.* In such systems, only part of the power passes through the "auxiliary unit". In the systems shown in *Figures 1 & 2,* all the power passes through the "speed changer" or the "frequency converter", respectively. This distinction gives us our fifth rule:

• *Size and weight of CFVS generators may be reduced by converting and adjusting only part of the input power.*

This principle can be applied within individual parts as well as within the system as a whole. For instance, in one proposed speed-changer design, a major part of the power is transmitted mechanically from input to output by a differential. The power handled by the electromagnetic portions of the speed changer is decreased, and size and weight are reduced accordingly.

Many other important factors relate to the power flow in complex systems. For example, power may be made to flow in either direction through the "auxiliary unit". This fact is important because there is an optimum flow pattern that will improve efficiency.

When the generator's ultimate output member is not a synchronous machine, the reactive current for the load may present a problem. Since aircraft loads commonly need lagging current, the generator must be charged with the weight of any auxiliary apparatus needed to supply this current.

A synchronous machine may be made to supply reactive current by adjustment of the field excitation. By over- or under-exciting the machine, it can be made to maintain the voltage while supplying an output in which the line current lags or leads the line voltage as required by the load (*Fig. 5*). Our sixth rule gives the basic test in the matter of supplying both reactive kva and real power:

• *The output member of any system that can supply both in-phase and reactive current must be capable of instantaneous power flow in either direction (which, however, does not necessarily have to be of equal amplitude).*

Aside from the conventional synchronous generator, other machines meet this test, such as the one for which we have discussed adjustable-frequency ac rotor excitation to keep the output frequency constant as the speed varies. Also in this category are systems using a varying-frequency generator that supplies power to a frequency converter using electron tubes or semiconductor switches (provided the input and output line voltages are both either positive or negative).

Encouraging approaches have been found

Naturally, any system capable of instantaneous power flow in only one direction cannot supply reactive current. It must be operated in conjunction with a separate reactive volt-ampere source. This category includes mechanical contactor-type converters, mercury jet choppers, magnetic-amplifier converters, and induction generators.

In spite of the problems of generating constant-frequency electric power from a varying-speed engine, several encouraging approaches have been developed. The aircraft manufacturer can help these succeed by re-examining the application requirements in the light of the basic capacity of the proposed new power generation systems. For example, systems using semiconductor devices, which don't have any appreciable short-time overload capacity, in effect must be designed to meet the overload requirements of the application on a continuous basis. Are present overload specs realistic enough, considering the increased significance of the requirements?—End

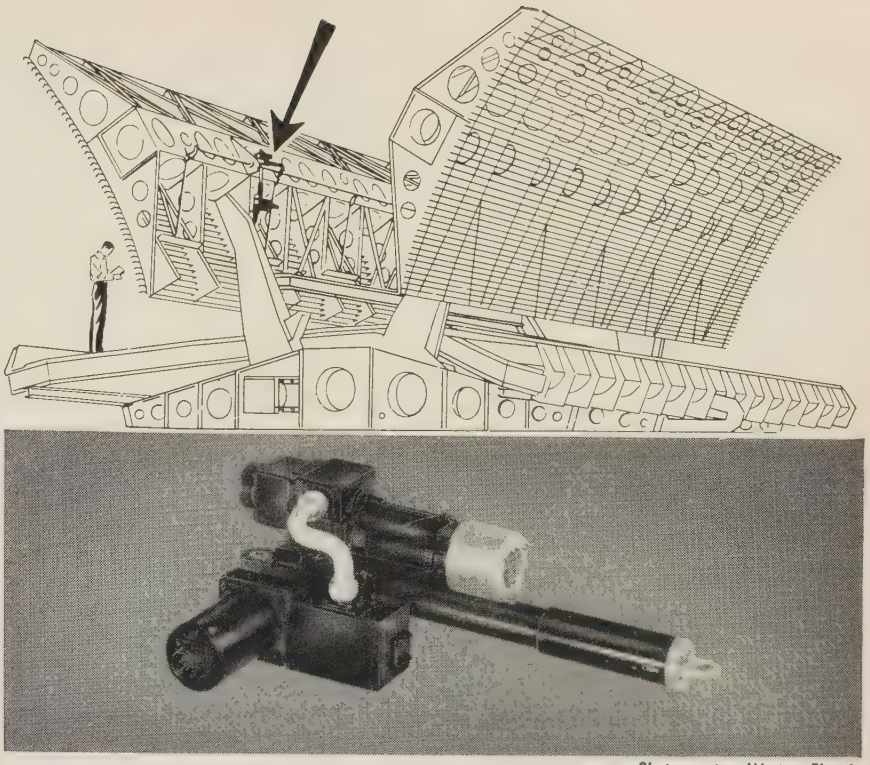


Photo courtesy Western Electric

R2552 LINEATOR exemplifies Airborne capabilities in large special actuators. Installed in pairs, units control tilt and shape of DEW Line antenna reflectors, must operate in temperatures from —65 to +130°F.

Airborne large special actuators used for DEW Line antenna control

Airborne large special actuators are being employed today in a diversity of applications, both air and ground. On the DEW Line, for example, pairs of Airborne R2552 LINEATOR actuators are used to control the tilt and shape of AN/FPS-19 antenna reflectors. Environment in this instance involves extreme temperature and humidity conditions and these call for a high order of mechanical and electrical reliability.

The R2552 typifies Airborne's capabilities in developing large special actuators—linear or rotary. And where requirements are not unique, we also offer a line of modular-type actuators, originated by Airborne to simplify design and specification. Write for further information.

GENERAL ENGINEERING DATA

Airborne Special Design
LINEATOR Actuator R2552

1. 208 v a-c, 60 cycle, 3 phase reversible induction motor with magnetic brake
2. Speed at rated load of 400 lb.: .3 in./sec.
3. Ambient temperature: –65 to +130°F. (–80°F. non-operating). Relative humidity: up to 100%
4. Design incorporates 2 limit switches and 4 intermediate position switches, plus synchro position transmitter.

AIRBORNE®

Engineered Equipment for Aircraft and Industry

AIRBORNE ACCESSORIES CORPORATION

HILLSIDE 5, NEW JERSEY • Offices in Los Angeles and Dallas

Write in No. 81 on Reader Service Card at start of Product Preview Section

LINDE's NEW PLASMARC TORCH SERVICE

Brings Industry Production Parts From Refractory Metals

No other method of fabricating refractory metals can match this. . . . The high melting points of tungsten, tantalum, and molybdenum are no longer a problem. For LINDE's new *PLASMARC* Torch, working in the temperature range between 15,000 and 30,000 degrees K., can coat parts or form shapes of virtually any size or complexity. It's an entirely new way to make such articles as rocket nozzles, crucibles, components for electronic and X-ray use, and parts for atomic energy equipment!

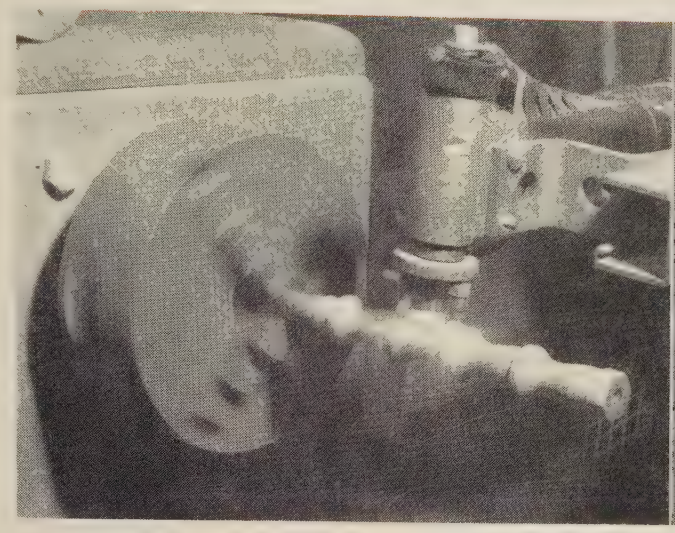
The quality of these pieces is uniformly high. Tolerances can be held to ±.002 in. or better. The metal loses none of its purity and superior density is achieved.

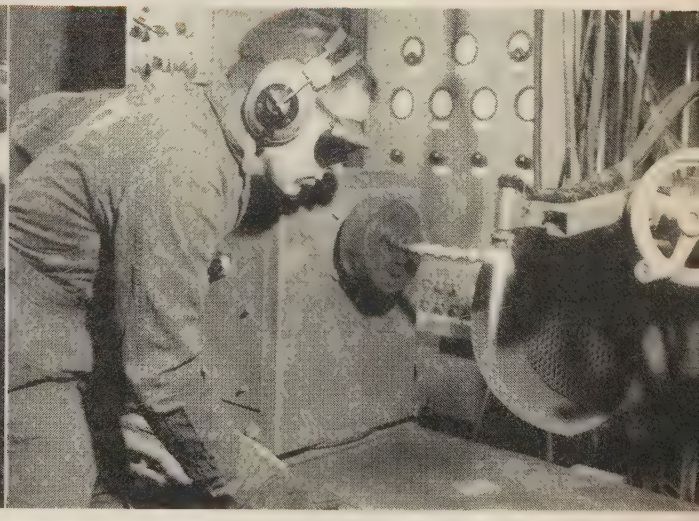
With the *PLASMARC* Torch, LINDE is equipped to supply you with parts made of, or coated with, refractory metals; or made of a variety of metals combined with non-metals or reinforced plastics. LINDE will also provide a wind-tunnel materials testing service based on this device. For information on this extension of LINDE's well-known Flame-Plating service, write Dept. AW-13, LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N.Y. In Canada: Linde Company, Division of Union Carbide Canada Limited.

The *PLASMARC* Torch employs a non-transferred electric arc to generate such high temperatures that powder or wire fed into the chamber is literally melted. Inert gases flowing continuously carry the metal particles in a plastic state and deposit them on the workpiece at near-sonic speeds. Jets of CO_2 cool the particles instantly to form heat- and erosion-resistant material. Coatings—even on graphite—have an excellent bond. Shapes are built up on machined mandrels, which are then etched away to leave parts such as those shown above.

Linde UNION CARBIDE

"Linde", "Union Carbide" and "Plasmarc" are trade marks of Union Carbide Corporation.





MINIATURE rocket liners are being formed on a multiple mandrel by Linde's plasma arc process. This technique can also be used to coat any material that does not decompose when it melts, say company engineers.

Plasma arc process

coats and forms refractory materials

How to work hard-to-form refractory materials has been a major problem in high temperature design. Plasma technology offers a way of overcoming it—and also helps meet the requirement for superpure materials for advanced electronic designs.

PLASMA technology promises to open up many new areas for designers—it is pointing the way to new materials as well as to new methods of using materials. A good example of this development is the "plasma arc" process devised by Flame Plating Dept., Linde Co., 30 E. 42nd St., New York 17, N.Y., to apply coatings of fabricate complex shapes or refractory materials with special plasma arc torches.

Typical materials that can be applied by this new method are tungsten, tantalum, molybdenum, niobium, rhenium, alumina, zirconium oxide, nickel, aluminum, copper, iron, zirconium diboride, platinum, palladium, etc. Actually, Linde researchers told SPACE/AERONAUTICS, any material that does not decompose on melting can be worked by the process.

The plasma is obtained by heating gas to a temperature high enough so that it's at least partly ionized. Temperatures above 20,000 deg F have been attained inside the arc column, Linde states. A layer of cool, non-ionized gas is used to insulate the arc from the nozzle.

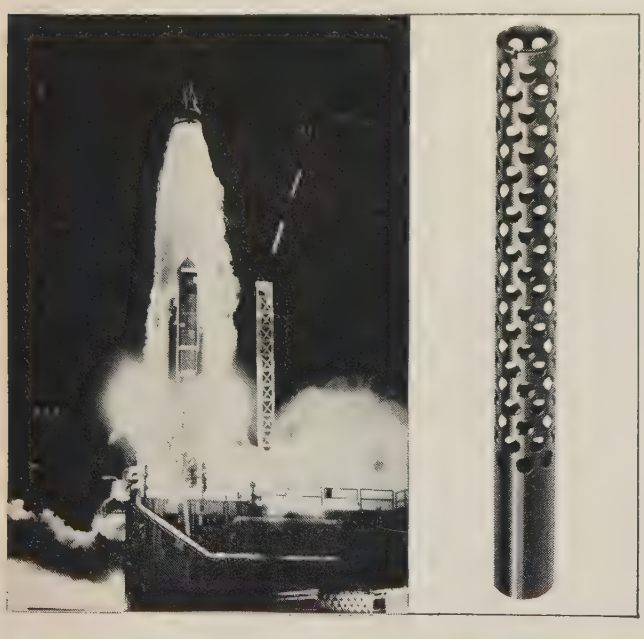
For the coating or forming operation, a "non-transferred" arc is

more on page 107

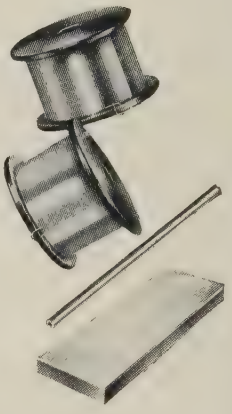
←Write in No. 82 on Reader Service Card

BISHOP QUICK SERVICE TEAM SOLVES STICKLER IN ATLAS PROGRAM

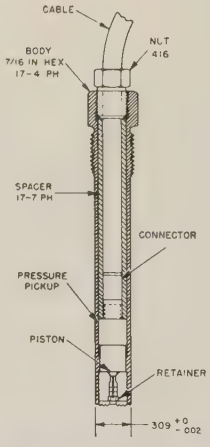
Telemetering bulb part (illustrated)—originally of 304 seamless tubing—cracked during fabrication. BISHOP specialists were called in—304L seamless, ½ hard was recommended and supplied (against a tough deadline). *Results:* The 304L part met all requirements, including critical resistance to vibration fatigue within a temperature range of -80° to -380°F in inert helium, and gave completely satisfactory performance in the Atlas program. More information on 304L—or any BISHOP tubular products? Use the coupon.



BIMETALLICS NOW AVAILABLE IN MANY DIFFERENT FORMS, METALS



Bimetallics—the new family of composite metal products—is solving problem after problem these days. BISHOP capabilities in producing bimetallics are almost endless. Both *base* and *precious* metals are available in wire, sheet, and tubing form. *Typical example of popular bimetallic for glass sealing applications:* nickel-iron alloys over copper wire in sizes from .004 to .125 in. diameter . . . advantages: *low* electrical resistivity, *good* thermal conductivity. Look into the possibilities of improving *your* products . . . use the coupon.



17-7 PH* TUBING BEING DRAWN TO HYPODERMIC SIZE

Small diameter 17-7 PH tubing, welded and seamless, is available from BISHOP now on standard order in sizes down to .375 in. OD X .035 in. wall—on special order to .020 in. OD X .006 in. wall. Accompanying illustration shows a piezoelectric transducer used for measuring pressures up to 100,000 psi in ballistics and hypersonic research work. Use of welded 17-7 PH spacer in transducer permitted finish machining of the part *before* heat treating. Want more data on BISHOP'S 17-7 PH products or other super alloys? Use the coupon.

**Trademark of Armco Steel Corporation*

J. BISHOP & CO.
platinum works

FOR HELPFUL DATA USE THIS HANDY COUPON

- ☐ **Bimetallics,** Data Sheet PA–1
- ☐ **17-7 PH alloy,** Data Sheet TA–2A
- ☐ **304L alloy,** Data Sheet TA–2
- ☐ **Tubular Products,** Bulletin No. 12
- ☐ **Platinum Metals Products,** Catalog No. 3

Check information you'd like and mail to
J. BISHOP & CO.,
50 King St., Malvern, Penna.

Name
Position
Company
Address
City Zone State

Tubular Products Division

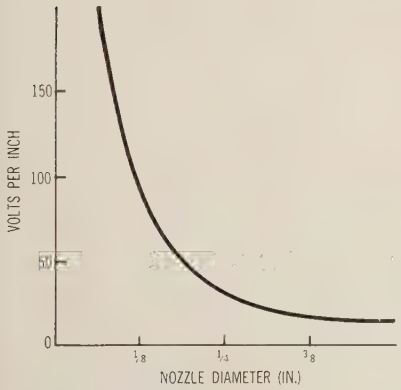
50 KING STREET, MALVERN, PENNA.

NIagara 4-3100

THIS IS THE BISHOP LINE:
Products of all the Platinum Metals...
Small diameter Stainless Steel,
nickel and special alloy tubing

Write in No. 83 on Reader Service Card for Telemetering Bulb
Write in No. 84 on Reader Service Card for Bimetallics
Write in No. 85 on Reader Service Card for 17-7 PH* Tubing

AMONG parts produced by the plasma arc process are graphite rocket nozzles coated with tungsten (center and on the mandrel), tungsten nozzle liners (right), and tungsten and tungsten-coated tubes (top).



VOLTAGE gradients for plasma torch nozzles of various sizes at 200 amp and 20 CFH argon.

used—the arc is struck over a short distance and is entirely contained within the torch housing. The substance to be worked is fed into the arc in wire or powder form (see *Schematic*). Melted particles are then carried to the desired location by an inert gas at speeds as high as 1500 fps and set up a firm bond to the underlying material.

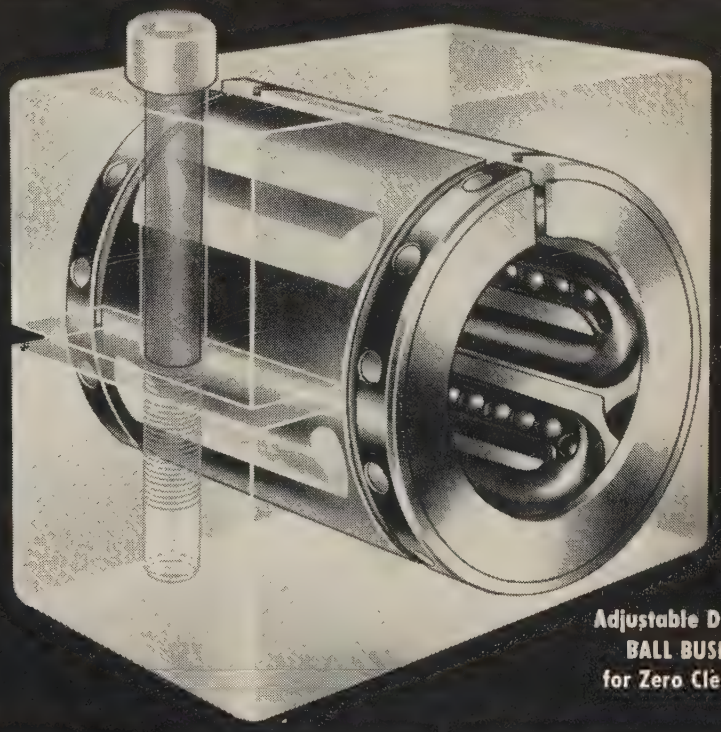
Typical coating applications involve such parts as rocket nozzles. For instance, excellent tungsten-coated graphite parts have been provided on a production basis. In another case, platinum and palladium coatings on Alumel-Chromel thermo-couples helped prevent failure due to exfoliation and oxidation.

Coatings have also been successfully applied to reinforced plastics, researchers report. These coatings, they state, are very dense, usually laminar in structure, and may be finished to below 10 uin.

more on next page

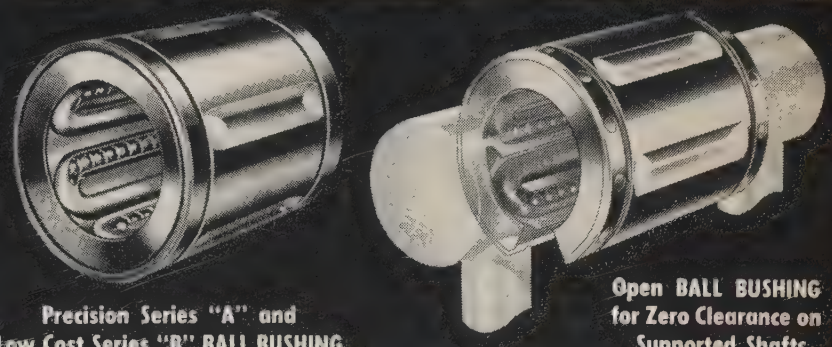
Write in No. 86 on Reader Service Card

NOW! *Adjustable Diameter and Open*
THOMSON
BALL BUSHINGS



Adjustable Diameter
BALL BUSHING
for Zero Clearance

The BALL Bearing
for *all* your
LINEAR MOTIONS



Precision Series "A" and
Low Cost Series "B" BALL BUSHING

Open BALL BUSHING
for Zero Clearance on
Supported Shafts

Sliding linear motions are nearly always troublesome. Thousands of progressive engineers and designers have solved this problem by application of BALL BUSHINGS on *guide rods, reciprocating shafts, push-pull actions,* or for support of *any mechanism that is moved or shifted in a straight line.*

Improve your product! Up-date your design and performance with Thomson BALL BUSHINGS!

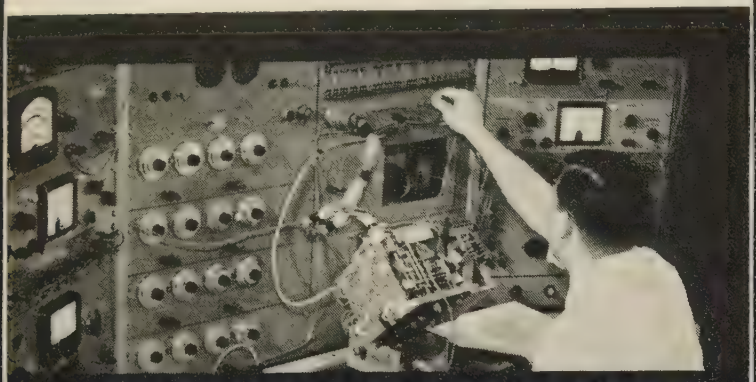
LOW FRICTION • ZERO SHAKE OR PLAY
ELIMINATE BINDING AND CHATTER
SOLVE SLIDING LUBRICATION PROBLEMS
LONG LIFE • LASTING ALIGNMENT

The various types cover a shaft diameter range of 1/8" to 4". Small sizes available in Stainless Steel. Write for literature and name of our representative in your city.

THOMSON INDUSTRIES, Inc.
Dept. D, MANHASSET, NEW YORK

Also Manufacturers of NYLINED Bearings . . . Sleeve Bearings
of DuPont Nylon, and 60 CASE . . . Hardened and Ground Steel Shafting

RESOLVERS—WHEN AND HOW YOU WANT THEM AND AT MASS PRODUCTION PRICES



Checking resolver chains in E-P Dead Reckoning Computer System.

From twenty years' experience in designing and manufacturing resolvers, *we have developed the means of predicting exactly how resolvers of various mechanical and electrical characteristics will perform in your system under any given operational conditions.*

Nothing could be surer. You tell us the system performance you need. We analyze the requirements and supply the resolvers which will help bring you that performance. If none of our many standard resolver models fills the bill, we'll build "specials" that will.

Because we make, as standard items, just about every type of resolver and other synchros, we can usually deliver quickly and at volume production prices. Available are frame sizes 8, 10, 11 and 15. We also make cascaded resolver chains, using resolvers as small as frame size 10 with accuracy of 1/6° without using booster amplifiers.

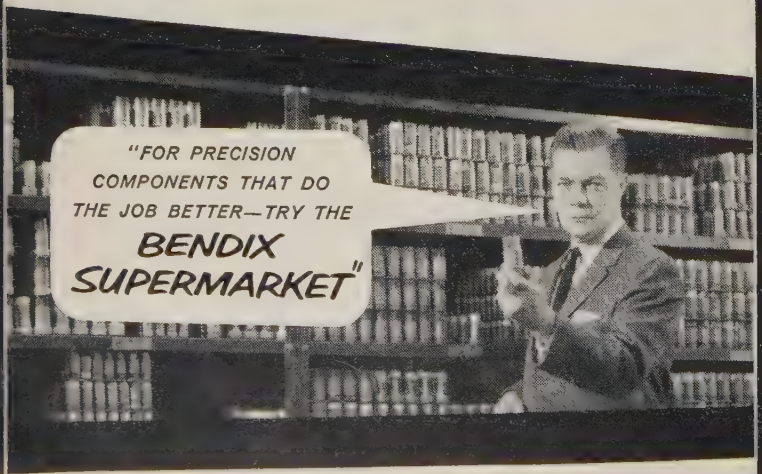
MORE FOR YOUR MONEY. Our unique ability to pre-determine performance—and then to "tailor-make" to your needs—means that you get maximum value for your component dollar. Write for details.

Eclipse-Pioneer Division

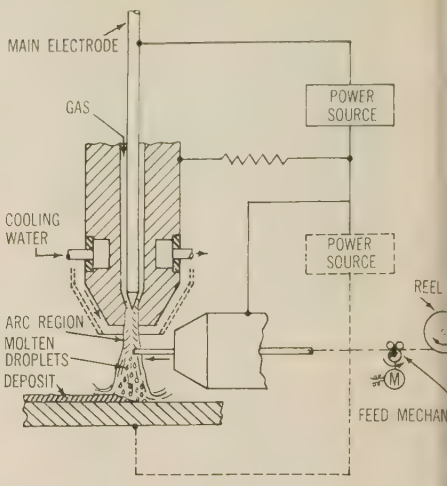
Teterboro, N. J.

District Offices: Burbank and San Francisco, Calif.; Seattle, Wash.; Dayton, Ohio; and Washington, D. C. Export Sales & Service: Bendix International Division, 205 E. 42nd St., New York 17, N. Y.

Bendix AVIATION CORPORATION



Write in No. 87 on Reader Service Card at start of Product Preview Section



WIRE FED Plasma Arc torch developed by Linde. Different type of torch design is used for materials in powder form.

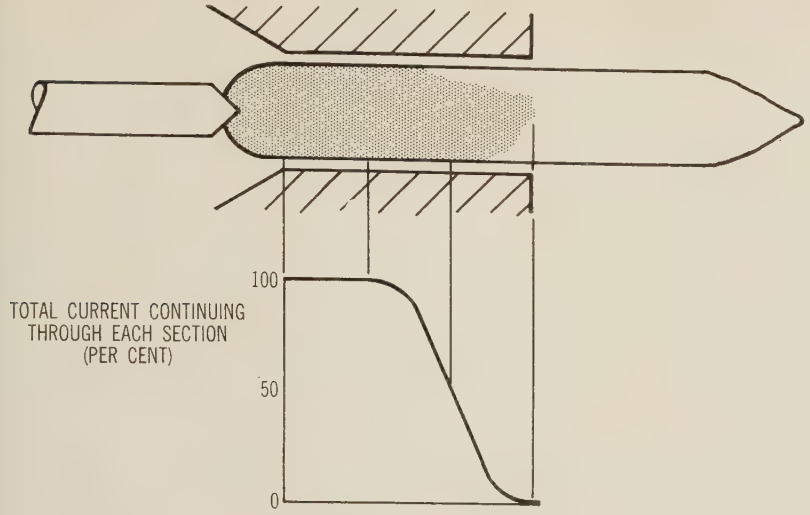
A major advantage of the process, SPACE/AERONAUTICS was told, is that no impurities are added to the material that is being worked. If a powder is fed into the arc, for instance, what comes out at the other end is as pure as what was put in, since the electric arc has no impurities in it. In other processes, it's pointed out, chemical means must be used and can introduce impurities.

Pure electronic material is needed.

Superpure materials are becoming important in a number of areas, particularly in electronics. In the past, the purity of materials wasn't too important in this field. Now, however, with operating frequencies and temperatures up, the picture has changed.

A case in point is the semiconductor industry. The upper frequencies of semiconductors are limited by impurities, Linde engineers state. This fact makes it necessary for example, to melt silicon for transistors in as pure an atmosphere as possible. Plasma technology can help out here by making it possible to produce high purity crucibles.

In another case, a manufacturer of microwave tubes had erosion (secondary emission) problems with a new design. The higher powers of the tubes had higher energies, which caused erosion of the



CURRENT distribution in ¼-in. diameter plasma torch nozzle at 100 amp and 30 CFH nitrogen.

cathode. A tungsten coating seemed called for. But on a mocrowave tube, not just any coating would do the job. The plasma arc process, Linde states, made it possible to solve the problem.

The plasma arc method can also be used to form complex and accurate parts from hard-to-form materials. In one case, for instance, a tungsten crucible was needed that had to be 1/16 in. thick and three inches high. Studies showed it was impossible to do the job by conventional fabricating methods, engineers state. The plasma arc process was then used, and crucibles of the proper wall thickness were formed to ± 0.002 in.

To make such shapes by the plasma arc process, the material is deposited on a mandrel. When the desired thickness is obtained, the mandrel is chemically removed.

This method has been used to make a wide range of electronic components, such as grid bars, grid cages, X-ray targets of great purity, etc. One example is a thin, high purity tungsten cathode. Current practice on such a part is to take a thin tungsten tube and wrap it around a framework. In this case, the part would have had to be thicker than was desirable if it was to have enough structural strength for wrapping. The final part also would have been dimensionally inaccurate.

The part was then made to extremely close tolerances by building up a thin layer of tungsten on a copper mandrel by plasma techniques. The thinner wall thus gained, it's noted, helped provide much better heat transfer properties.

Purity is also becoming very important in the basic-metal field. The plasma setup is essentially a furnace in which there are no walls. It's pointed out that with, say, an aluminum or steel furnace, some of the brick will get into the melt—no matter how carefully the furnace is prepared. While tremendous amounts of power would be needed for large-scale plasma furnaces, such units are still conceivable.

Many experimental uses of plasma technology are being examined. For instance, when certain materials are passed through the arc, single crystals tend to form. Researchers are currently looking into the possibility of making a relatively large bar of single-crystal structure. Whisker experiments indicate such a bar might be immensely stronger than any material available today.

Linde doesn't plan to market any plasma arc equipment at present. One reason for this, SPACE/AERONAUTICS was told, is that the equipment is complex and required a capable technician to monitor it. However, it's pointed out that the equipment isn't a laboratory tool either, since it will run continuously until shut off. Linde thus is prepared to accept orders for coating or fabricating parts on a production or experimental basis. Circle No. 65 on Reader Service Card for more information—**IS**

P.S. and don't forget these other quality products at the

BENDIX "SUPERMARKET"

With our greater variety and greater volume of the precision components listed below, we have become the "supermarket" of the industry. We feature fast delivery and mass-production economy—plus the highest precision quality.

400-CYCLE SYNCHROS
(Frame sizes: 8, 10, 11, 15, 22)
Control Transformers
Differentials • Receivers
Transmitters

GYROS
Directional, Free, Rate, Roll and Vertical Gyro Transmitters • Stable Platforms

MOTORS AND GENERATORS
Gear Head Motors and Motor Generators • Low-Inertia Servo Motors • Motor Generators • Precision Induction Tachometer Generators • Rate Generators

PACKAGED COMPONENTS
Analog-Digital Converters • Azimuth Counters • Cam Compensators • Clutched Synchros • Dual-Speed Synchros • External Slip-Ring Synchros • Follow-Up Mechanisms • Miniature Differential Gear Assemblies • Servo Assemblies

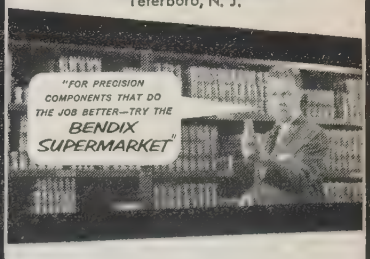
RADAR DEVICES
Airborne Radar Antennae • Ground Antenna Pedestals

YcBTBS

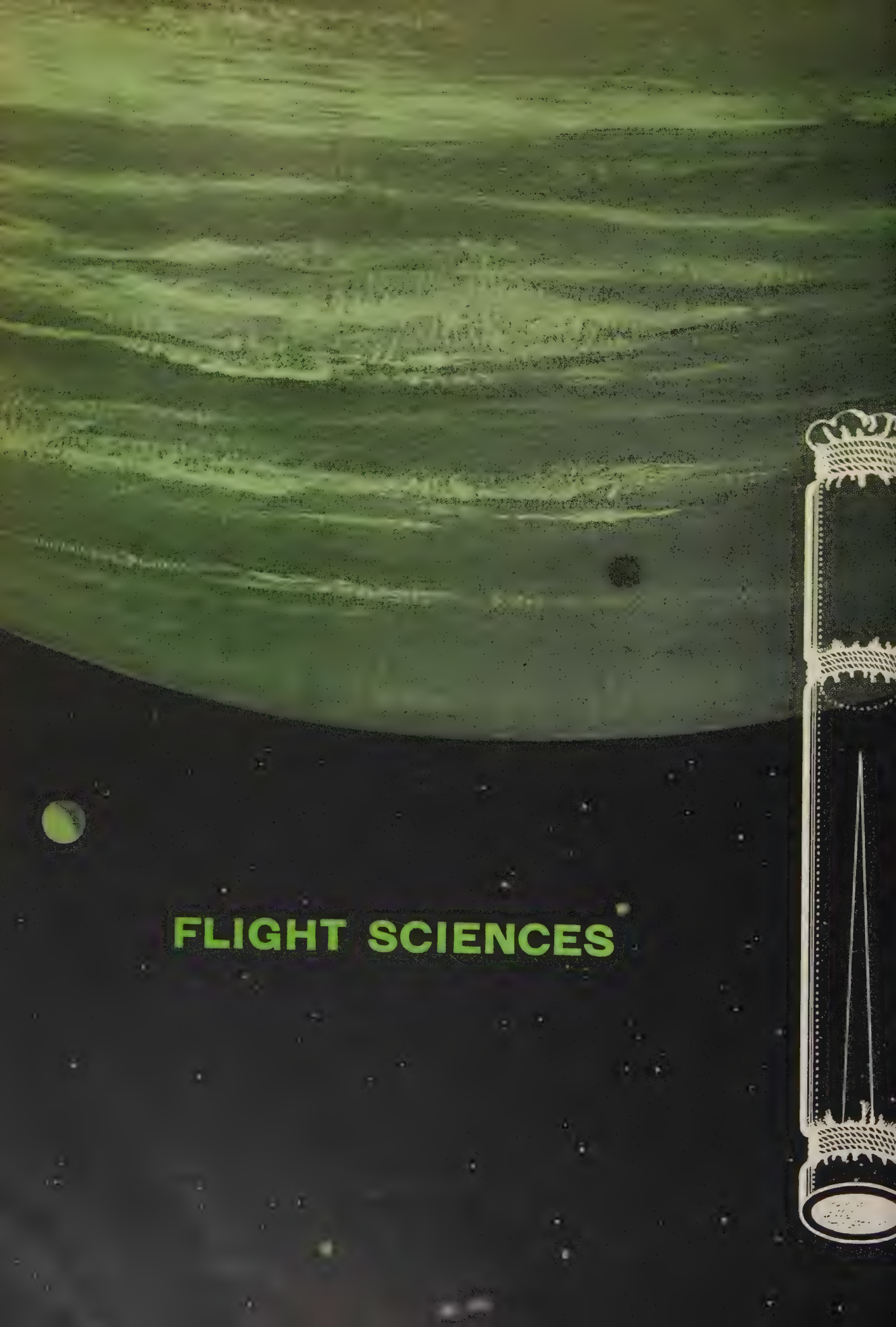
You Can't Beat The Bendix "Supermarket". Try us.

Eclipse-Pioneer Division

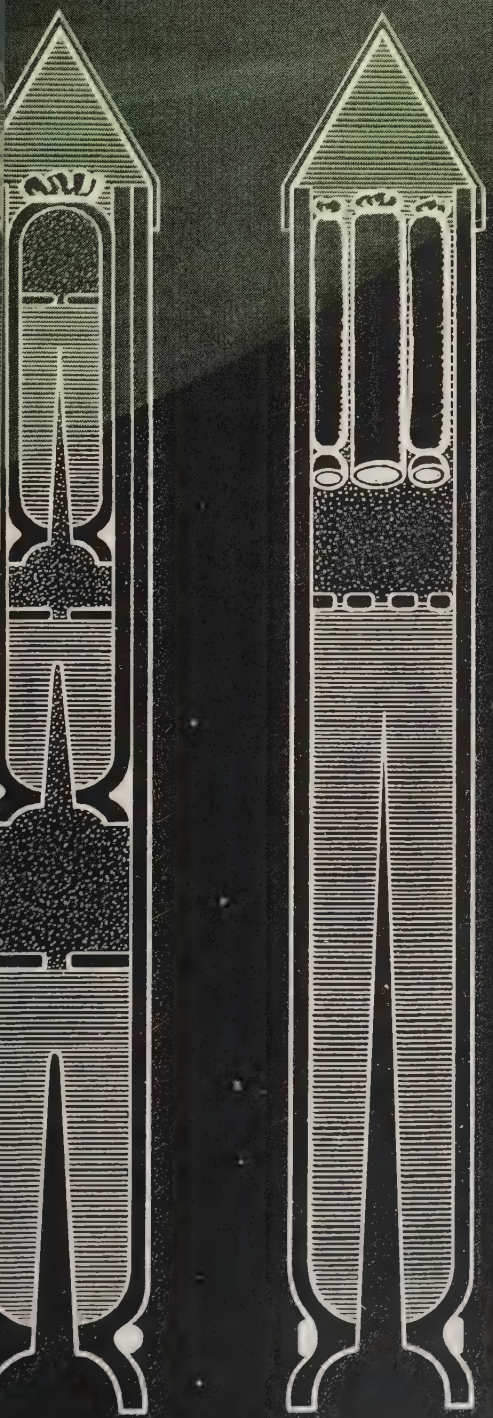
Bendix
AVIATION CORPORATION
Teterboro, N. J.



Write in No. 88 on Reader Service Card


FLIGHT SCIENCES

FLIGHT SCIENCES: Principle of the step or multi-stage rocket, considered fundamental to the art of modern missiles and space flight, was set forth as long ago as 1650 by Kazimierz Siemienowicz, lieutenant-general of ordnance to the king of Poland. His design featured a 3-stage rocket with each step having its own gunpowder fuel, fuse, and nozzle.



EXPANDING THE FRONTIERS OF SPACE TECHNOLOGY

Pioneering work at Lockheed is being conducted in free molecular flow in orbital flight; high altitude atmospheric properties; trajectory studies and missile flight dynamics; celestial mechanics with emphasis on orbital tracking predictions and de-orbiting.

Lockheed's capabilities in gas dynamics and thermodynamics are unsurpassed in private industry. Basic work is being performed in boundary layer flow and heat transfer; cooling and insulation; thermodynamic flight test; instrumentation; rocket motor controls and nozzle structures; reentry and materials; thin film thermometry; and measurements of dissociation and re-combination reactions.

Fundamental studies include hypersonic aerodynamics; environmental effects on satellite surfaces; magnetohydrodynamics; ultra-violet and infrared radiation from high temperature air flows; structure of hypersonic shock waves; new measurement methods; analysis of boundary layers near melting surfaces and study of lag or non-equilibrium in high speed flow through shock waves.

Equipment includes an electrically-driven wind tunnel—fastest in industry—which produces airflows to Mach 20-plus and stagnant temperatures approaching 16,000°F, with an instantaneous power output of 20 million kilowatts. A spark-heated, magnetically driven research shock tube produces velocities of over Mach 250 and temperatures of 500,000°F, and a specially designed, electric gun has accelerated projectiles to speeds approaching 20,000 ft/sec.

Major emphasis in structures concerns the design of reentry bodies, thrust termination and underwater launching devices. The Navy Polaris FBM required the solution of complex structural problems necessitated by the unique launching environment—water.

Other significant work has been accomplished in diversified aspects of aerodynamic and hydrodynamic load distribution, aeroelastic effects, studies of special dynamic problems arising from aerodynamic disturbances, cavitation, launching conditions and thermal problems relating to analysis of a complex structure taken through a complete time-temperature environment.

Lockheed Missiles and Space Division programs reach far into the future and deal with unknown environments. It is a rewarding future which scientists and engineers of outstanding talent and inquiring mind are invited to share. Write: Research and Development Staff, Dept. G-16, 962 W. El Camino Real, Sunnyvale, California.
U.S. citizenship required.

Lockheed

MISSILES AND SPACE DIVISION

Weapons Systems Manager for the Navy POLARIS FBM; DISCOVERER SATELLITE; Army KINGFISHER; and Air Force Q-5 and X-7

SUNNYVALE, PALO ALTO, VAN NUYS, SANTA CRUZ, SANTA MARIA, CALIFORNIA
CAPE CANAVERAL, FLORIDA • ALAMOGORDO, NEW MEXICO • HAWAII

But if you want to try, do this:

- Spend 20 years applying advanced metallurgy to production.
- Shake down 35 high-temperature alloys in the laboratory.
- Fabricate these super-alloys into critical hot-part components for prototype power plants.
- Swing into volume production of proved designs.
- Prove, over and over again, that you know what you're doing—with jet, propjet and piston engine components and afterburners, ramjets and rocket motors.
- Make your name a byword for high-temperature research and development... for precision-made components and complete power packages.

Better still—take a 20-year stride by putting Ryan to work on your heat problems.

RYAN BUILDS BETTER

AIRCRAFT · POWER PLANTS · ELECTRONICS

Ryan Aeronautical Company, San Diego, Calif.

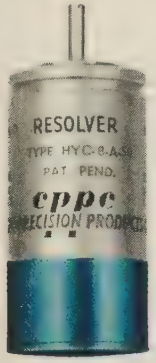
Write in No. 89 on Reader Service Card at start of Product Preview Section

space/aero Electronics

Lightweight Inertial Platform
(see Design Digest p. 128)

advanced
PRECISION COMPUTING RESOLVERS
for
Cascaded Resolver Systems

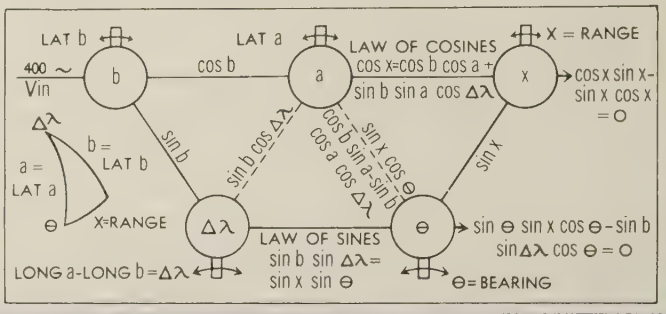
SIZE 8 FEEDBACK WINDING RESOLVERS



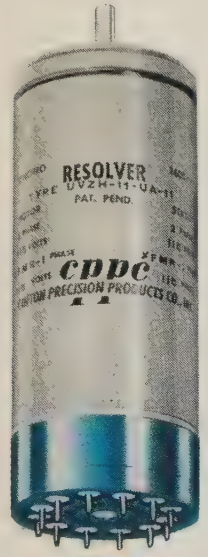
These resolvers are designed for use with transistorized amplifiers and permit the solution of spherical triangles in a size 8 cascaded resolver chain.

Functions of the spherical triangle which can be produced are indicated in the schematic below. More complex trigonometric functions, as well as systems involving coordinate axis transformation, can be generated with the use of these resolvers.

Accuracy: Functional error .1% or less; winding perp. ±5′. Electrical characteristics: Input voltage 15v400~ (stator); output voltage 13.7v (rotor); phase shift (stator as primary) 20.5°; output voltage 13.7v (compensator); Zro 234 + j596; Zso 244 + j548; Zcompensator 237 + j553; max. null voltage 1 mv/v.



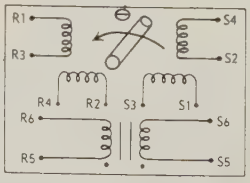
SIZE 11 AMPLIFIERLESS RESOLVER FOR ANGULAR DATA TRANSMISSION

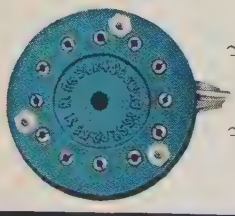


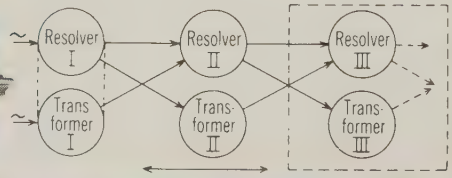
These size 11 resolvers incorporate an integral transformer which simulates a resolver function at maximum coupling. They are used in the typical chain application indicated below for angular data transmission. In this particular application, the output information can be servoed at either end of the chain.

Quick disconnect allows ease in harnessing.

Accuracy: ±5′ of arc or less; winding perp. ±5′. Electrical characteristics: Input to EITHER rotor or stator. Input voltage 115v1600~; output voltage 110v both stator and rotor as primary; phase shift (stator primary) 1.1°; phase shift (rotor primary) 1.9°; Zso (nom.) 990 + j13500; Zro (nom.) 1150 + j13500.







SIZE 11 RESOLVER TRIMMED FOR ZERO PHASE SHIFT CONTAINS ALL COMPENSATION IN 2¼″ LENGTH

The YZC-11-E-1 precision computing resolver has been developed for use in a cascaded, amplifierless resolver system at 900~.

These units have been trimmed to provide zero phase shift and compensated for transformation ratio stability, under temperature, when working into their iterative impedance.

Accuracy: Functional error .1% or less; winding perp. ±5′. Electrical characteristics: Input voltage (stator) 40v900 ~; output voltage (rotor) 33.2v; phase shift 0; max. null voltage 1 mv/v.

Also ready for delivery is an equivalent, compatible pancake resolver. By its use, differential information from an inertial platform may be obtained and introduced into the system.

ENGINEERS — Join the leader in the rotating components field. Write David D. Brown, Director of Personnel, Dept. J7

cppc CLIFTON PRECISION PRODUCTS Co., INC.

CLIFTON HEIGHTS, PENNSYLVANIA

Sales Offices: 9014 W. Chester Pike, Upper Darby, Pa. — Ivanhoe 9-1200, TWX Flanders, Pa. 1122 — or our Representatives

Write in No. 90 on Reader Service Card at start of Product Preview Section

PROJECT DEFENDER, designed to produce futuristic super long range ballistic missile detection and interception systems, is one of the most "electronified" programs yet tackled by the Advanced Projects Research Agency. Its 100 per cent electronic parts are:

- omnirange digital radar—Columbia U. electronic research group ($1.328 million);
- ballistic missile defense system studies—Convair ($1.375 million);
- feasibility studies on satellite defense systems—Allied Research Assoc., Convair, Dikewood, General Atomic, GE, Lockheed, RCA, Republic ($3.085 million);
- feasibility studies, mainly on Glipar (*G*uide *l*ine *i*dentification *p*rogram for *a*nti-missile *r*esearch, see *S/A, Management Intelligence, June '59, p. 24*)—Aeronutronic Systems, Allied Research Assoc., U. of Chicago, Convair, General Atomic, GE, General Mills, Hughes Aircraft, Industrial Research Assoc., RCA, Republic, Stanford Research, Technical Operations, Thompson Ramo Wooldridge, Westinghouse ($1.78 million);
- digital phased array radar—Sylvania ($1.434 million);
- high power radar research—Cornell Aero Lab ($1.361 million);
- microwave radar—RCA ($850,000);
- decoy sorting radar—Raytheon ($1.18 million);
- radar discrimination—Raytheon ($680,000);
- advanced radar research—MIT, Lincoln Lab ($515,000);
- HF ionospheric radar research—ONR ($535,000);
- electronically steerable radar array—Bendix ($2.144 million);
- missile range measurements—ARDC ($3.435 million).

NEW UNDERWATER communications and detection technique is being developed by Piasecki's newly formed Electronic Div., which recently bought the rights to it from the inventor. "Mediowave" transmits electromagnetic waves and claims Piasecki, promises much greater underwater range and sensitivity than sonar.

Possible uses include submarine detection and underwater communications and guidance. Experiments, says Piasecki, show that the technique can also be used to transmit energy through the surface of the earth.

TARTAR WILL use a Pyroceram Radome. Corning Glass says that it has received an order from Convair to produce the glass-ceramic radomes for the ship-to-air missile.

HIGH TEMPERATURE wire insulation of fluoride was developed by two Bell Labs researchers. The coatings can be formed on copper, aluminum, and other metal wires and will stand temperatures up to the melting point of the wire itself. They are put on to a thickness of one to a few microns, permit flexing the wire, and will not crack when repeatedly bent 90 deg. Insulation resistance is on the order of 10^{10} ohms at room temperatures for a 1-2 micron insulative film.

ACOUSTIC TESTER bought by Autonetics from Transducers, of La Crescente, Calif., delivers 250 acoustic W to produce a sound pressure level of about 150 db. Device can simulate sounds met by electronic equipment under actual operating conditions in missiles and jet aircraft. Sounds can be taped and played back with any desired degree of amplification.

more on next page

375,000-lb pedestal and dish for BMEWS radar

PROTOTYPES OF BMEWS tracking radar assemblies and radomes are being made by Goodyear Aircraft. Radome will be a 140-ft-diameter rigid sphere. Pedestal to hold the huge dish will be three stories high. The Pedestal-and-antenna dish combination, one of the largest ever built, will weigh nearly 375,000 lb.

Radome walls will be six-inch thickness of paper pressed into honeycomb design and faced with plastic-impregnated fiberglass.

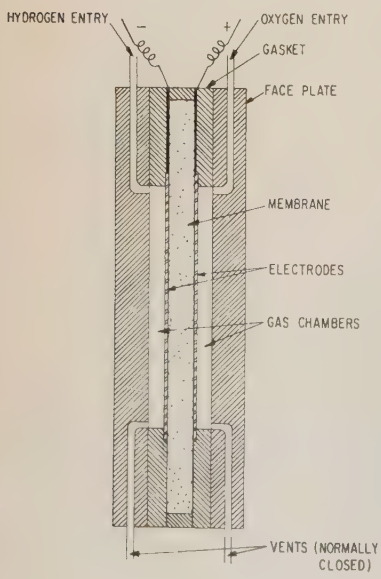
Cover story—Minneapolis-Honeywell's lightweight MIG stable platform is undergoing a test on a three-axis flight simulator. Inertial-quality gyros and accelerometers give the 25-lb platform an accuracy rivaling that of conventional 150-pounders, says Minneapolis-Honeywell.

SATELLITE-BORNE DEVICE for search and rescue of lost or stranded vehicles was proposed by Space Electronics of Glendale, Calif. The firm's Sarus (*S*earch *a*nd *r*escue *u*sing *s*atellites) system would be made up of a network of perhaps six satellites orbiting at about 1000 miles and each containing a Doppler radar for tracking the trajectories of falling missile nose cones, space capsules, or conventional aircraft and surface ships.

Using subminiature UHF radio transmitters, vehicles in distress could radiate signals for Sarus to follow. The satellites would record their Doppler findings, together with a time base that would fix their position in orbit, and transmit the stored information to ground stations upon interrogation. Sarus payloads, Space Electronics figures, would run around 20 lb and be made up of existing hardware.

NEW FUEL CELL (see *Schematic*) developed by GE's Research Lab uses hydrogen ions as the charged carriers, with water as the oxidant electrode. It consists of a round plastic disk about a half inch thick and three inches in diameter. It has a hollow interior divided into two chambers by a plastic membrane that has an electrode in contact with each of its sides.

Hydrogen feeds into one chamber and oxygen into the other. At one electrode, the hydrogen molecules break up into electrons and positively charged hydrogen ions. The electrons flow through the external circuit, developing a voltage, and the hydrogen ions move through the membrane to the other electrode, where they combine with the oxygen to form water.



CELL OPERATES at room temperature and atmospheric pressure. Thermal efficiencies over 60 per cent have been obtained, says GE.

GE has had some cells in test operation for over 100 days. Portions of the tests have been run at current densities of 30 ma/cm². On the basis of current data, GE has calculated power densities on the order of one to two kw/cu ft.

HAVING ALREADY garnered the subcontract for the F-108 central air data system, Air Research now got a similar contract for the B-70 from North American.

WADC REPORTEDLY is highly interested in an inertially referenced celestial space navigator proposed by Kellsman Instrument at a recent meeting of top USAF brass and representatives of the aerospace industry. The system would probably include a transistorized automatic multi-star tracker, an inertial platform, and a computer. It could track the sun for a vertical reference. Fixing two stars and a planet would give the spacecraft's latitude and longitude about the sun as well as the range. The system could use the line of sight to one of the stars for a steering reference.

PRESENT APN-22 low altitude radar altimeter, used by the military and made by Raytheon and Sylvania, suffers from "step function" errors that preclude its use for automatic landing.

GALLIUM ARSENIDE solar cells and tunnel diodes developed by RCA Labs will operate up to 750 deg F without appreciable loss of operating efficiency. The cells, claims RCA, promise higher efficiency over a wider temperature range than present silicon cells.

PADAR (*P*assive *A*irborne *D*etection *a*nd *R*anging system), developed by Fairchild's Astrionics Div., will be test-flown shortly for FAA. It will be tried out as an anti-collision device.

Gas and liquid devices may also be used for molecular electronics

MOLECULAR ELECTRONICS is not confined to solid-state devices. USAF's Cambridge (Mass.) Research Center is also looking into using the properties of matter in gaseous and liquid form for functions now performed by electronic circuits.

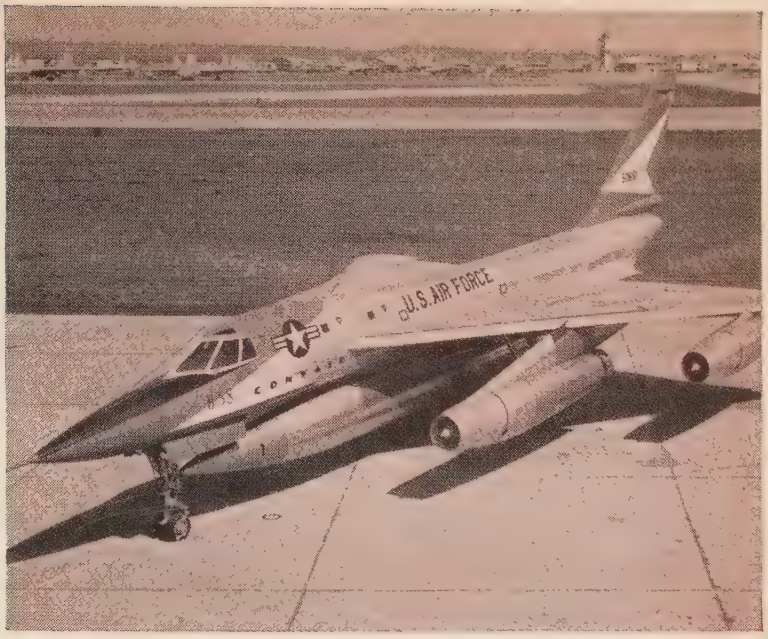
•

FOR NUCLEAR FLIGHT, new techniques may have to be developed to permit RF transmission and reception through the ionized sheath that would surround the vehicle, according to E. R. Pfaff and F. E. Graham, researchers at Ad-

more on page 118

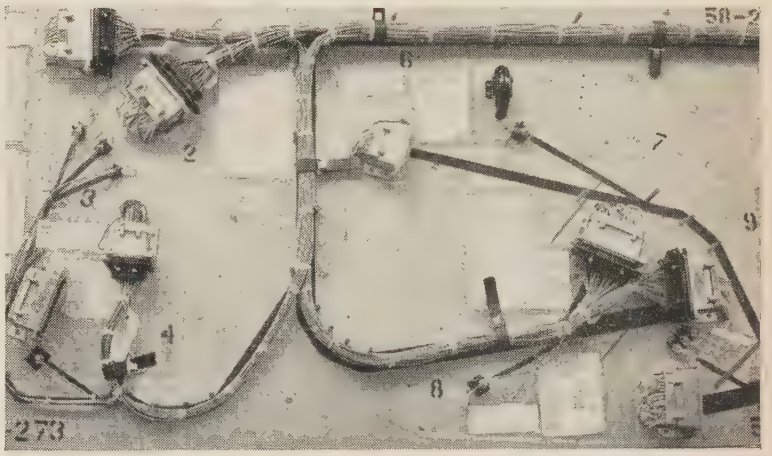
The PLANE

Convair's B-58 Hustler, supersonic delta-wing bomber. The B-58 is a high altitude craft, area-ruled for Mach 2 flight . . . capable of attaining altitudes above 50,000 feet. Now in production for USAF.



The PROBLEM

Insulation for the B-58's electrical wiring system must be flexible, solderable, withstand extreme temperatures, ozone, moisture, arcing, corona. Must meet MIL-W-8777 specifications. Wire bundle clamps must remain resilient under same extremes.



The PRODUCT

SILASTIC
SILICONE RUBBER

Wire covered with Silastic®, the Dow Corning silicone rubber, was specified throughout in the B-58. Wire bundle clamps are also Silastic.

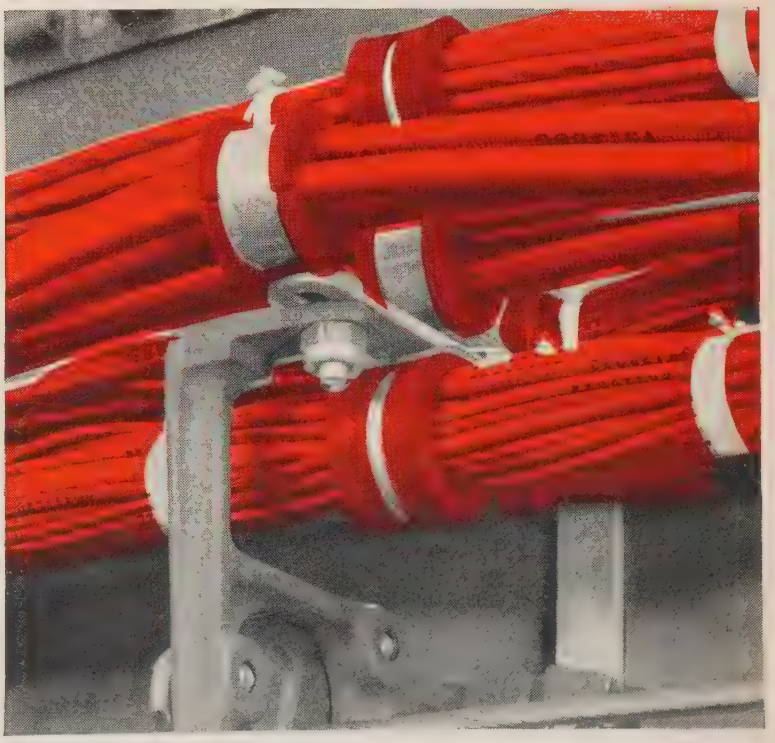
TYPICAL PROPERTIES OF SILASTIC FOR WIRE

Temperature range, °F	—130 to 500
Insulation resistance, megohms/1000 ft.	1000 to 3000
Electric strength, volts/mil	300 to 500
Dielectric constant, 10^2 cycles per second, nominal	3.2

For more information write Dept. 0719.

first in silicones

Dow Corning CORPORATION
MIDLAND, MICHIGAN



Write in No. 91 on Reader Service Card at start of Product Preview Section

miral's Nuclear Physics Dept. In a paper given at the 1959 Electronics Components Conference, they suggested that new antenna configurations and extremely high frequencies might pierce the sheath.

In nuclear vehicles, the ionized layer isn't confined to the skin of the vehicle (as on re-entry nose cones), it exists too within microwave components, such as waveguides and cavity resonators. Ionization will also limit the impedance level of circuit devices, claimed the Admiral engineers. The ionization effects, they said, occur only in the presence of some atmosphere and depend on the power level of the nuclear engine.

EFFECT OF NUCLEAR radiation pulses on electronic components is being studied in the Army Signal Corps R&D lab at Fort Monmouth, N.J. Studies are aimed at discovering how parts would stand up to the pulses from a nuclear explosion.

MERCURY, our first manned satellite, will be equipped with radar beacons to make it easier to track, reports Avion. Under a $434,805 contract from Collins, communications systems prime on the NASA project, Avion will furnish two types of beacons for the one-ton capsule—a low power crystal video unit and a high power, long range unit. Both beacons are passive.

U.S. and Soviet officials are impressed by British automatic landing system

BRITISH AUTOMATIC landing system impressed FAA officials as well as Russians in recent trials. The Reds, according to British press reports, spent £100,000 ($268,000) for two systems; FAA is definitely interested in taking a closer look.

Developed by the Blind Landing Experimental Unit (BLEU) of the Royal Aircraft Establishment, the system combines ILS (glide slope and localizer) and a radar altimeter. Additionally two parallel magnetic leader cables are stretched out about a mile before the runway to take over azimuth guidance from the localizer from a few hundred feet altitude to touchdown.

The ILS guides a landing aircraft along the extended centerline of the runway to 300 ft, where the glide slope guidance is cut out and the aircraft is held in its descending attitude to 70 ft. There the altimeter takes over to produce an automatic flareout and landing.

SOME 5000 SUCCESSFUL landings have already been made with the system. The British are apparently commited to install it at all major airbases in England.

Reports from U.S. observers are that the British are not altogether satisfied with either the localizer, made by Pye Telecommunications, or the radar altimeter, made by Standard Telephones & Cables. However, both units appear to be about as good as anything currently available anywhere in the world.

The main drawback of the system is the long leader cables that must be stretched out on a surface level with the landing runway. This could lead to serious real estate problems at many airports in the U.S.

FLAREOUT SYSTEM developed by North American Aviation (originally to recover the Navaho missile) will be made for USAF under a $600,000 contract partially funded by FAA. The APN-114 landing control set uses ILS to 200 ft and a combination radar altimeter and inertial system for flareout, beginning at 70 ft. Between 200 and 70 ft, NAA uses a prediction technique to keep the proper attitude and flight path.

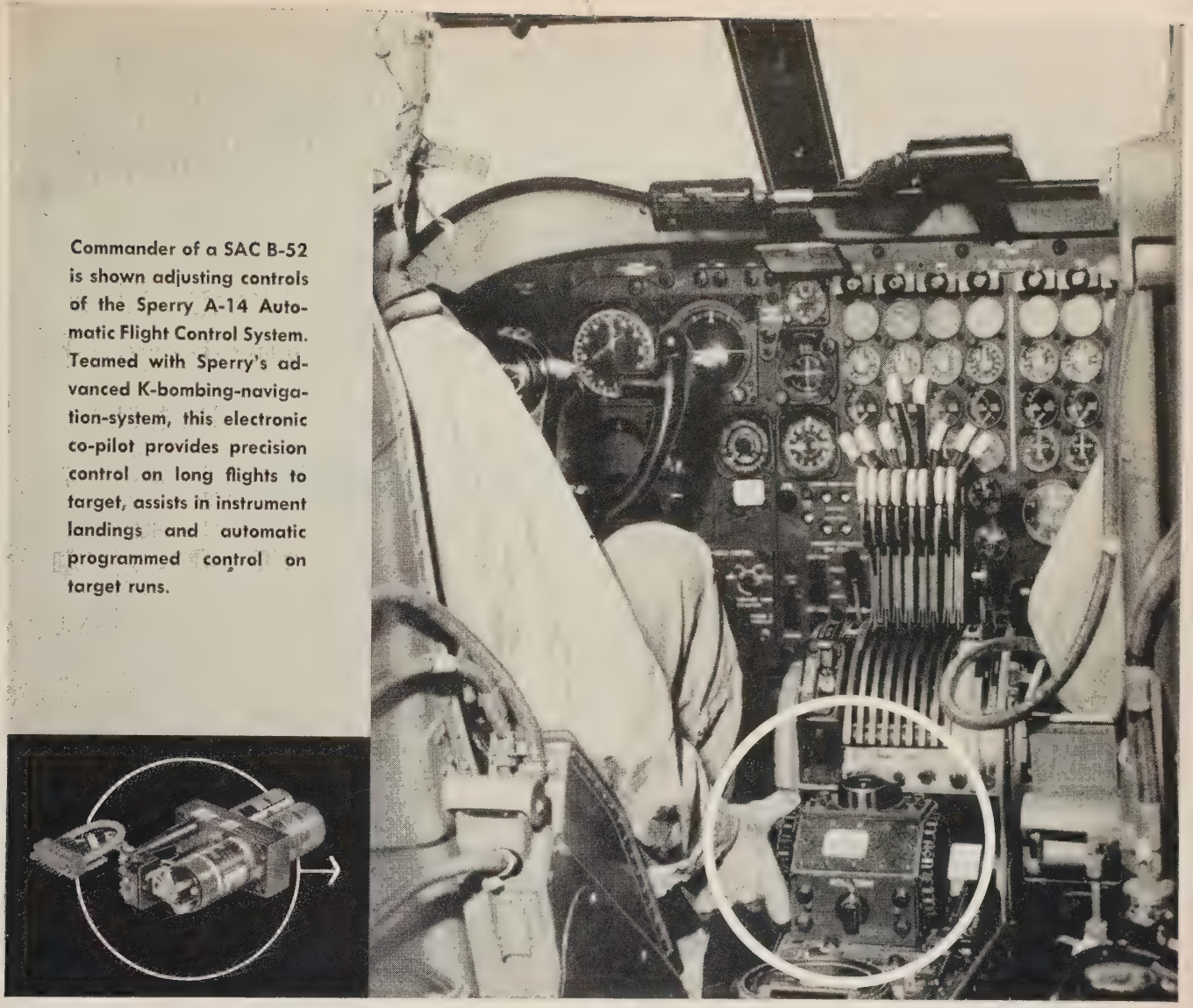
The radar altimeter used by NAA is a modified version of the APN-1. It is expected that the APN-100 radar altimeter, recently developed by Emerson Research, will be phased into system at a later date.

ANOTHER FLAREOUT system has been proposed to FAA by Minneapolis-Honeywell. It would be built around a very short pulse width radar altimeter.

ARMY Corps of Engineers is said to be putting the finishing touches to the physical structures at three ballistic missile early warning sites. RCA, prime contractor for USAF's BMEWS detection system will furnish the manpower to operate the stations for two years, or until USAF personnel get enough training. Western Electric is the prime on the communication system for the projected 15-minute missile warning net.

Each BMEWS station, tied in with Sage, will take advantage of the existing Dew-line communications net. Plan is for instantaneous warning to be relayed to operational units of the Air Defense Command.

Commander of a SAC B-52 is shown adjusting controls of the Sperry A-14 Automatic Flight Control System. Teamed with Sperry's advanced K-bombing-navigation-system, this electronic co-pilot provides precision control on long flights to target, assists in instrument landings and automatic programmed control on target runs.



servo assist for sperry's electronic co-pilot

When the commander of a B-52 gives his Stratofortress the order to execute this or that maneuver, the control system of his "electronic co-pilot" automatically applies just the right force on the control surfaces to obtain the desired maneuver under the prevailing flight conditions. That's automatic flight control at its finest!

Daystrom Transicoil helps provide the calculated muscle for this flight system in the form of servo controlled pitch, roll, and yaw follow up; coordination integrator; and pitch integrator. Only the highest level of accuracy, performance, and reliability will do . . . for you, for us.

The engineering and manufacturing assistance you need to turn modern system requirements into optimized working sub-systems and assemblies is the very basis of our business. Contact us direct or through our local representative. Check into our 24 Hour Service on servo motors and generators. Daystrom Transicoil, Division of Daystrom, Inc., Worcester, Montgomery County, Pennsylvania. (Phone: JUNO 4-2421)

DAYSTROM TRANSICOIL DIVISION OF DAYSTROM, INC.

Representatives in Canada and Other Foreign Countries

Write in No. 92 on Reader Service Card at start of Product Preview Section

The payoff of missile design:

electronic fuzing

The whole point of a missile is that it should deliver its warhead just when and where it will do the most harm. It follows that the fuzing system is one of the most important parts of a missile. The most sophisticated and lethal device in the fuzing family is the proximity fuze, which calls for top-drawer electronic design.

by William H. Doty, Director of Engineering, Electronic Specialty Co.*

AN ELECTRONIC FUZING system may be defined as one in which detonation occurs in response to an electromagnetic variation caused by a target in the neighborhood of the system. This definition excludes some systems commonly considered electronic, such as missile destruct linkages and intervalometers, because they do not use electromagnetic phenomena as a primary determinant for detonation. (In missile destruct, the electronics is essentially a telemetering system. The basic phenomenon that controls detonation is the closing of a switch in response to some non-electronic missile parameter. The intervalometer is a timing device preset as a function of some external source of range information.)

Electronic fuzing came into its own during World War II with the development of the famed radio proximity fuze. This fuze proved to be four times more effective than time fuzes in bringing down enemy aircraft. By the war's end, proximity fuzes were operational in field artillery shells, bombs, and rockets, increasing the effectivness of these weapons from five to 20 times.

U.S. efforts in "prox" fuze development concentrated on optical and radio types. Both proved practical. The optical fuze operated in response to sunlight reflected from the target. It consisted of a directional toroidal lens, a photocell, and an amplifier. The toroidal lens, mounted in the nose of the fuze, had a hollow cone of vision—essentially a conic surface—extending forward. When a target crossed any portion of this conic surface, the light input to the cell increased sharply. The sudden increase was a signal for detonation.

By setting the angle of the conic detection surface to correspond with the fragmentation pattern of the projectile, the detonation signal was generated only when the target was in the densest part of the fragmentation pattern. The optical system was detonated by the sudden change of light input produced as a target crossing the surface of vision, and not by the absolute magnitude of light input. It therefore could be used under widely varying ambient light conditions. However, because of its inherent limitation to daytime conditions, it was replaced when radio fuzing systems became available.

Radio fuze had a CW transmitter

The radio fuzing system contained a CW transmitter and responded to RF signals reflected from the target. Due to the Doppler shift, the frequency of the reflected signal (F_R) is:

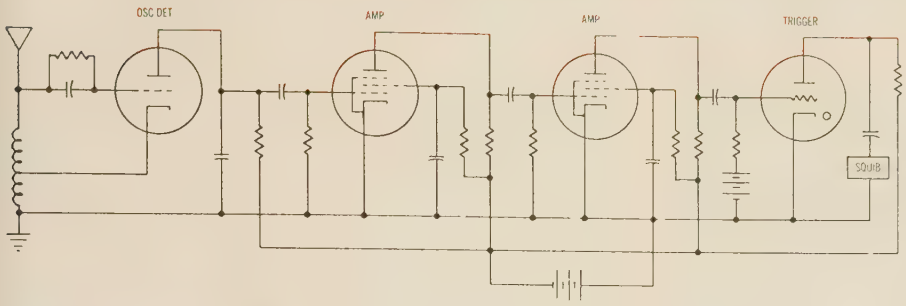
$$F_R = f_o + 2\,(V_r/\lambda),$$

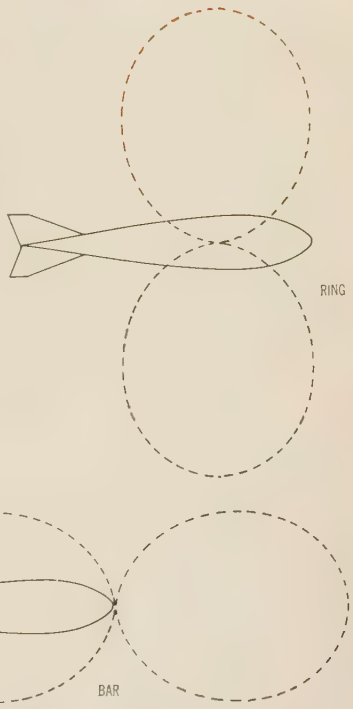
where f_o is the transmitted frequency; V_r the relative velocity between fuze and target; and λ, the wavelength of the transmitted signal.

In the transmitter, the reflected signal beats with the outgoing signal to produce a difference beat frequency of $2(V_r/\lambda)$ in the oscillator plate circuit. This difference frequency is then amplified and applied to the firing circuit.

How the Doppler frequency is detected in the oscillator plate circuit can be understood by consider-

*Electronic Specialty Co., 5121 San Fernando Rd., Los Angeles 39, Calif.





RADIO PROX FUZES used in World War II (above) had simple circuits. Their job was to set off artillery shells or bombs. Current fuzes often use transistors. Right: Ring- and bar-type antenna patterns. In many fuzing circuits, the amplifier design is closely tied in with the antenna characteristics.

ing the effect of the target on antenna radiation resistance. If the reflected signal induces an opposing current in the transmitting antenna, the net antenna load is lowered and the transmitting oscillator is presented with a higher radiation resistance. When the reflecting object comes a quarter of a wavelength closer, antenna current is increased, lowering the radiation resistance.

Therefore the relative motion can be interpreted as a cyclical variation of radiation impedance that, to the oscillator, looks like a sinusoidally varying resistive load. The sensitivity of the oscillator-detector is defined as the change in difference voltage at the oscillator plate per unit change in radiation resistance. Class C oscillators were generally used with this circuit, because of their high sensitivity and a stability that is largely independent of tube characteristics and total radiation resistance.

Amplifier design in the Doppler circuit is closely tied to antenna characteristics and tactical considerations. Detonation occurs when the amplified difference voltage reaches the firing level of a thyratron. The amplifier must therefore be designed to take into account the reflecting characteristics of the target, the angle of approach, sensitivity and directivity pattern of the antenna, the nature of the explosive, the fragmentation pattern, and the physical nature of the target.

For example, for maximum effectiveness against ground targets, it is desirable to have a uniform burst height relatively independent of approach angle. This can be achieved by adjusting the gain vs frequency characteristic of the amplifier to compensate for variations in the angle of approach. The exact characteristics used depend on whether the antenna is a ring or bar type.

The bar antenna is a dipole disposed at right angles to the projectile axis (see *Diagram*). The radiation of the bar antenna toward the ground is substantially constant over a wide range of approach angles, and little compensation is needed for changes in angle of approach. Therefore the amplifier used with this antenna is designed for flat response over the Doppler frequency range.

In the ring-type antenna, however, the pattern extends at right angles to the projectile's axis. The radiation to the ground is therefore sensitive to the angle of approach. It is weakest for a vertical approach and increases as the angle with the vertical is increased. But the Doppler frequency is also sensitive to the angle of approach—being maximum for a vertical approach and decreasing as the radiation to ground increases.

Uniform burst height was achieved

Thus a uniform burst height can be gotten with a ring antenna by designing the amplifier for high gain at high Doppler frequencies, tapering off to low gain at low Doppler frequencies. In this way, the amplifier frequency vs gain characteristic compensates for changes in signal level from different angles of approach to the ground.

The design considerations in the case of aerial targets are quite different from those with ground targets. Against an aerial target, the projectile must be exploded at the optimum point as it passes the target. This point is determined by the fragmentation pattern of the projectile and its velocity. The greatest concentration of fragments is usually at right angles to the projectile axis, but the fragments also have a velocity parallel to the projectile axis that they have acquired before the explosion. Therefore the optimum point for detonation is slightly forward of the fragmentation pattern; its exact location is a function of projectile velocity. In most cases, the optimum point for detonation occurs where the line from the projectile

more on next page

Prox Fuze Business

The market for missile proximity fuzes has been variously estimated as running from $50 to $250 million per year. As anti-ICBMs are developed and go into production, this figure should considerably increase, says fuzing company spokesmen.

The Air Force's Special Weapons Center, at Kirtland AFB, recently let a contract to Electronic Specialty for the Panda all-weather FM-CW radar fuze, specially designed for atomic missiles. The contract, it is figured, will amount to about $30 million per year for three years, if Panda proves successful. Panda might also be picked as the standard prox fuze for all air-to-air and ground-to-air missiles, claims Electronic Specialty.

It is believed that Panda will be first used in Douglas' Genie air-to-air atomic missile.

to the target makes an angle of 15-30 deg with the normal to the trajectory.

Doppler frequency is the electric determinant of the angle between projectile and target. At long range, the closing velocity between projectile and target is maximum, but it decreases as the projectile approaches and falls to zero when the target is directly abeam of the projectile. (In a direct hit the frequency remains relatively constant, of course, but since the projectiles also are fused mechanically, this is no problem.) Against aerial targets, therefore, the amplifier is sharply tuned to the Doppler frequency corresponding to the best detonation angle.

Wet-Cell battery suplied power

The Doppler radio fuze was used in artillery shells, bombs, and rockets. The electric power source in the artillery fuze was a wet-cell battery whose electrolyte was enclosed in a breakable container as a safety feature. The battery plates were disposed annularly around this container in such a manner that combined setback and spin were required to generate the operating voltage. Shock from firing ruptured the electrolyte container, and spin (imparted by the rifling) distributed the electrolyte over the annular battery plates.

The fuze included several other safety features. A mechanical safety gate isolated the detonator charge from the booster charge, so that accidental ignition of the detonator wouldn't set off the booster. The mechanical gate moved only in response to high spin rates, mechanically disabling the projectile until it was fired.

There was also a high charge resistance in the firing capacitor circuit. Detonation occurred when a charged firing capacitor was discharged through an electric detonator via a thyratron. The RC value was chosen so that it delayed the charge build-up to the critical firing level for a fixed time following activation of the battery. Thus the circuit was disabled until the projectile had traveled a safe distance from the muzzle.

Still another safety device was a mercury switch that normally shorted the detonator squib. It was opened by projectile spin.

Bomb fuzes got their electric power from wind-driven generators. Because of the low temperature at high altitudes, batteries were impractical. The generator also has the obvious safety feature of zero output until exposed to a wind stream.

One of the greatest problems in designing artillery fuzes for mass production was component ruggedness. Each component was subject to acceleration on the order of 20,000 G on firing. The development of components to take this shock was a major achievement, particularly in the case of electron tubes.

The Doppler radio fuze would run into severe limitations if used against modern airborne targets. It's sensitivity, for instance, which was adequate for projectiles with lethal ranges around 100 ft, is far too small for nuclear weapons.

To see what might best be used against today's manned aircraft and missiles, let's examine the known electromagnetic fuzing systems. There are eight major types, classified by the way in which they sense nearness to the target: capacitive, inductive, magnetic, visible light, infrared, Doppler radio, pulse radio, and FM-CW radar.

Capacitive systems operate by measuring the capacitance between the weapon and the target. They detonate the weapon when the capacitance exceeds some preset level. A sensitive capacitance bridge circuit can be used or an oscillator that relies on the capacitance-detecting element in an oscillator tank circuit.

The major advantage of this detector is immunity to jamming. To cause premature detonation of a capacitive system, an object similar to the target in size and capacitive characteristics must be present. There is no known method of projecting an object of this size into the path of a missile. In addition, there is no known way of preventing a change in capacitance when a missile approaches its target.

Premature detonation is possible

But this system has some serious drawbacks. It can be detonated prematurely by capacitive changes due to ionized gases, or a local mountain range on the target bearing but below the target path. These changes could approximate or even exceed the change resulting from approach to the target. Because of the probability of a missile's rotating about its own axis, the detector must be symmetrical, and there is no possibility of removing susceptibility to missile-to-ground capacitance without lowering the target detection range.

Another major drawback is that the normal capacitance level can't be determined until after the missile has traveled far enough from its launching vehicle or device to reduce the capacitive influence of the launcher. Steady-state capacitance would have to be balanced out in flight at a point depending on the target range. This process would require a fairly high order of sophistication and could be quite expensive in terms of weight and power requirements. Though the capacitive detector is virtually jam-proof, its circuit limitations will probably preclude development of an effective system for aerial targets.

The *inductive* detector, which has been used successfully in locating land mines and mineral ore, detects the presence of magnetic materials in a low frequency magnetic field. The presence of magnetic material in the inductive field changes the mutual inductance balance of two or more coils connected in a bridge circuit, with the imbalance depending on the size and nearness of the material. Detonation would occur at a preset output level from the bridge.

The inductive detector is difficult to jam, since it operates below the frequencies ordinarily monitored by enemy aircraft. It is not as susceptible to changes in earth characteristics as the capacitance detector, but could possibly be affected by swirling ionized trails from jet engines.

Major drawbacks are large weight and power requirements for long range detection and in-flight balancing. Like the capacitive detector, the inductive detector must be balanced at some point between its launcher and the target. In a comparison with other detectors, these disadvantages outweigh the advantages.

The *magnetic* detector uses a magnetometer. When a magnetic object enters a magnetic field, the field is distorted by an amount depending on the object's size. This distortion increases the field strength elsewhere. Therefore the field strength seen by a magnetometer increases as a target is approached.

Against aerial targets, the magnetic detector requires very sensitive detecting elements and high gain amplifiers, since the effect of an aircraft on the earth's magnetic field is quite small. Also, it is estimated that local deviations exist in the earth's magnetic field of of the same order as those caused by an aircraft, and these local deviations could cause premature detonation.

A detector generating its own field would be subject to the same limitations (sensitive detectors, high gain amplifiers, and local deviations). In addition it would require a very large power source.

Production models of a *visible light* fuzing system operated by reflected sunlight were developed early in World War II, but were immediately replaced by radio fuzes, since the latter could be used at night, too. This situation still applies today, and we need consider only systems in which light is generated in the weapon. If a continuous radiation of light were attempted, a 64,000,000-W source would be required to produce a signal equivalent to a 100-W microwave signal in the 1000-mc range. In view of the facts that they are easy to jam and are adversely affected by clouds and sunlight, further study of visible-light detectors does not appear worthwhile.

Infrared detectors operate in response to IR radiation from the target. They are susceptible to premature detonation by high heat flares and also if launched toward the sun, a rather efficient generator of IR energy. Against the latter danger, an angle tracking system might be used for detonation when the target is approximately abeam, but there would still be a possibility that the tracking circuits might lock onto the sun.

Tracking rate would be too high

Furthermore, the tracking circuits would require a fantastically high tracking rate of 87 rad/sec to determine when the target is abeam at short ranges. This means a tracking loop bandpass of 14 cps—difficult to obtain in any device and particularly so in view of the weight and volume requirements of missiles.

The *Doppler radio* fuze can be very easily detonated by ECM radiation from the target, and the normal level of Doppler return is too low to achieve the long range detection required by nuclear weapons, particularly against small targets. Therefore, although this system is still the best for field artillery, it is of limited value against present aerial targets.

Pulse radar systems can easily meet today's range and sensitivity requirements but involve serious technical problems connected with pulse width and repetition rate. The required minimum range is so small compared with propagation time that pulse widths would have to be in the millimicrosecond region. For example, if a minimum range of 100 ft could be allowed, the "round trip" time of travel for a radiated pulse would be $2 \times 100/980$ usec, or 1/5 usec. For a good square-topped pulse shape, the rise and fall time of the modulator output should be in the order of 20 millimicroseconds. A pulse of sufficient amplitude to modulate the power output tube having these rise and fall characteristics would be very difficult to attain with the given space, weight, and power limitations. Short, sharp pulses also imply a receiver band width in excess of 10 mc, which is quite vulnerable to jamming and difficult to design.

To get enough information for intelligently determining the correct firing time, at least 10, and preferably 20, pulses should be generated as the target passes through a 10-deg angle just ahead of the weapon's beam. At maximum velocity and with the weapon 100 ft from the target (which gives the shortest flight-time within the 10-deg angle and so the lowest pulse repetition rate), the weapon must travel 100 times the tangent of 10 deg, or 17.6 ft, to traverse the 10-deg interval.

Pulse system costly and complex

At Mach 10, it takes 17.6/9830 sec, or 1790 usec to traverse the 10-deg interval. Therefore, since 20 pulses are desired in this time interval, the time between pulses is 1790/20, or 89.5 usec. With this value for the basis period, the pulse repetition frequency would become 11,800 pps. With a pulse length of 0.2 usec, and a pulse period of 85 usec, the duty cycle for the output tube would be 0.2/85, or 0.00236—which is not compatible with the duty cycle ratings of available microwave pulsed oscillators.

Because of the very short pulses required and the rather high pulse repetition frequency of 11,800 pps, a radar system using pulse techniques becomes a rather complex and costly affair.

The *FM-CW radar* system combines the best features of the Doppler radio and pulse radar systems without the disadvantages of either. FM-CW radar, which has been used for years in the familiar radio altimeter, radiates a signal that is continuously varied in frequency. When a reflected signal is returned to the device, the local oscillator frequency will be changed by an amount depending on the round trip transit time of the reflected signal, which is a function of target range. Therefore, with compensation for Doppler shift, the difference between outgoing and incoming signal frequency indicates the target range.

Long detection ranges can be achieved easily with this system at relatively low power output and without complex pulse forming circuitry. In addition, the system has a continuous information input, and can operate with sharply tuned IF circuits that make jamming difficult. The unit can operate in a wide range of frequencies, but the L-band would probably be best, because high transmitter power is easy to attain at this frequency range and the range vs power characteristics are good.—End

Are we ready for space probe data transmission?

FIGURE 1: Artist's sketch of space-stabilized probe with directional antenna and reaction jets for orientation.

The success of our early studies of outer space depends largely on the effectiveness of communications between the earth and unmanned probes. And effective communications, this article argues, in turn will prove to be a matter of refining available equipment and techniques.

by William F. Sampson, Section Head, Space Communications, Hallamore Electronics Co.*

THE SUCCESS of space exploration by unmanned vehicles depends entirely on the amount and the quality of the data provided by the instrumentation and data transmission systems. In principle as well as in hardware, conventional telemetering equipment is capable of performing the required data transmission. However, the extent to which it can be used is limited by weight and volume restrictions set by the payload of the rocket-powered vehicle.

These restrictions may be interpreted as limits on the amount of power and total energy the data transmission system can use in relaying data back to earth. Power requirements are set by range, noise levels, the desired rate of data transmission, and accuracy specs. The amount of information to be transmitted sets the total energy requirements.

* Hallamore Electronics Co., Anaheim, Calif.

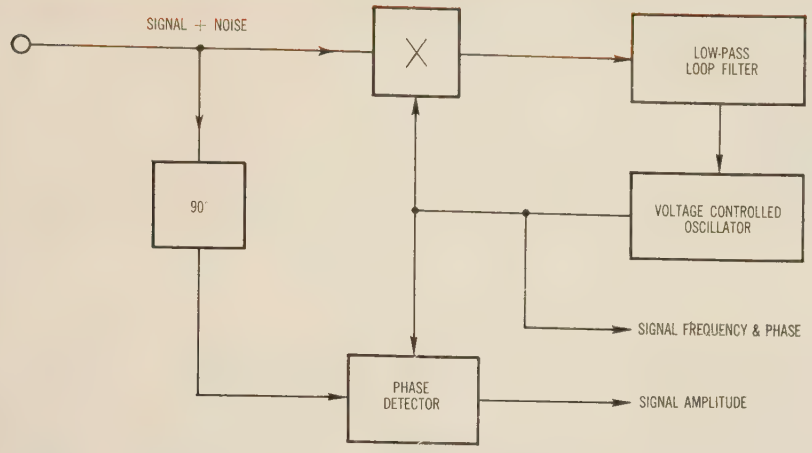
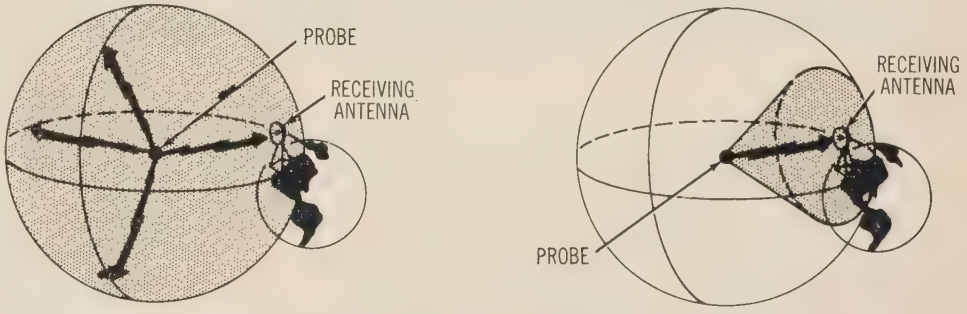


FIGURE 2: In phase-lock communications, a local estimate of the transmitted signal is generated by a voltage-controlled oscillator (VCO) and multiplied in the phase detector, The dc error voltage from the detector is separated from noise by a low-pass filter and used to control the VCO. A second phase detector produces a dc voltage proportional to the signal amplitude.

FIGURE 3: Radiated energy from a probe without a directional antenna is spread uniformly over the surface of a sphere (left). Some of it is intercepted by an earth-based receiver. Concentrated radiation in the direction of the earth (right) would make better use of the energy available for data transmission.



The basic problem is to make the power and energy allotments, in the form of battery or power supply weight and space, compatible with the power and energy requirements for a successful experiment. The best approach to this problem is to minimize the power and energy requirements of the vehicle-borne equipment and to get the most power from given weights of energy sources.

At any given range, the power output required of the data transmission system is dictated by the ability of the ground-based receiver to detect the transmitted signal in the presence of both received and self-generated noise. The greater the ratio of signal power to noise, the greater must be the power of the signal radiated by the vehicle transmitter.

Noise has three prime sources

Noise is present at all times and has three prime sources:

- extra-terrestrial noise, such as that resulting from radiation from celestial bodies;
- natural terrestrial noise, such as lightning, atmospheric disturbances, and auroras;
- man-made terrestrial noise from radio transmission equipment, engine ignition systems, power lines, fluorescent lights, and the noise of the receiving equipment circuits themselves.

Reducing the celestial noise level is very difficult. It is impossible to choose the time and place of launching to take full advantage of potential low noise situations (as arise, for instance, when the receiving antenna can be directed away from the Milky Way). Some finite noise level always is present. It is actually this level that combined with the capabilities of the receivers, sets the power requirements of the system.

Generally speaking, to minimize the power and energy required of the vehicle transmission system, you must: (1) improve the receiver's ability to detect low level signals, and (2) maximize the amount of transmitted power reaching the receiver terminals. These efforts cover the entire range of communications system elements, from the shape of the space vehicle to the transmission frequency.

Unfortunately, there is no ideal specification for each element of the system. Because of the extent of interaction between elements, you must make compromises in the design of the individual elements to get optimum performance.

Because of the limit that vehicle performance places on the power capabilities of the transmitter, you must try to better the performance of the ground equipment to achieve the largest gains. On the ground, weight and space, power, and equipment complexity may be traded for better performance without risking the success of the experiment.

One of the most significant improvements in ground equipment performance came with the development of the phase-lock technique of correlation detection. First used with the Explorer satellite, the technique is now the basis of lunar probe data transmission systems.

more on next page

FIGURE 4: Trailer-mounted phase-lock receiving equipment is teamed with a large directional antenna for collecting data transmitted from a lunar probe.

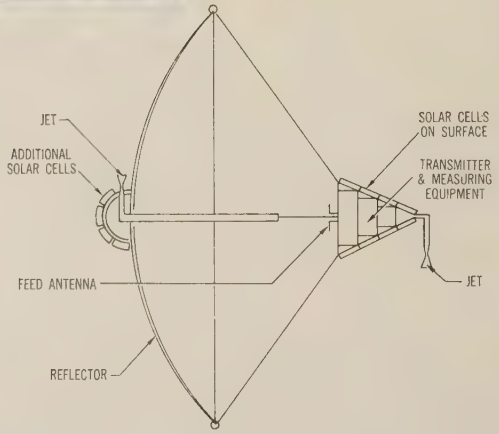


FIGURE 5: Cross-section of space probe.

In operation, a voltage-controlled oscillator (VCO) in the ground equipment of the phase-lock system generates a local estimate of the transmitted signal (*Fig. 2*). This estimate is compared with the received signal plus noise. The phase difference between the transmitted signal and the locally generated signal is averaged by the low-pass filter and used to maintain the local oscillator in phase synchronism with the signal coming from the vehicle.

Receiver threshold is lowered

The great advantage of the phase-lock technique is that it lowers tne threshold (minimum signal) level of the receiver, thanks to the unusual ability of the receiver to distinguish the transmitted signal from noise. In a typical detection and tracking system, phase-lock can reduce the required transmitter power by factors of up to 1000, compared with previously used techniques.

To a large extent, the frequency is determined by the required tracking accuracy. In traversing the ionosphere, radio signals suffer deviations in propagation angle that are proportional to the inverse of the square of the frequency. For instance, the 108-mc frequency in wide use today may be off by about one milliradian, or 3.2 minutes of arc. Despite this limit on accuracy, we may expect that, for locating the space vehicle's position by means of propagation angles, future explorations may demand even greater accuracies—on the order of 0.1 milliradians. To meet these needs, we'll have to consider using frequencies of around 350 mc or greater.

Unfortunately, attempts to lower deviation errors by means of higher frequencies are not without their problems. Frequency increases affect the performance of other system elements, particularly the transmitting and receiving antennas. To intercept the greatest amount of radiated energy, the latter are made as large as possible.

The difficulty lies in the fact that the directivity of the antenna increases with area for a fixed frequency and with frequency for a fixed area. Any increase in the directivity of the antenna requires more accurate aiming at the transmitting vehicle, if you're to intercept the maximum amount of power. Unless this tracking capability is provided, the advantage of increasing the interception area is lost.

Satellite and spacecraft tracking antennas have been built to diameters of 85 ft (*Fig. 4*), and super-antennas measuring 500 ft across have been proposed. However, the practical problems of training structures of this size with any great accuracy seem forbidding.

The amount of radiated energy reaching the earth from the probe transmitter is a function of the radiation pattern generated by its antenna. If a uniform, omnidirectional pattern is generated, the energy is dispersed in a spherical pattern. The earth-based receiving antenna intercepts an amount of energy proportional to the ratio of the antenna area to the area of a sphere whose radius equals the distance between receiving antenna and vehicle. Since space exploration will involve distances of hundreds of millions of miles, this ratio is discouragingly small (about 10^{-21} for an 85-ft diameter receiving antenna).

One means of increasing the proportion of total

radiated energy intercepted by the receiving antenna is to concentrate the major portion of the energy in the direction of the earth. Directional radiation patterns are needed in this approach and a system that maintains the concentrated beam locked on the earth. (*Fig. 3*).

Techniques for developing directed radiation patterns are well established and should present no problem. However, to keep a concentrated lobe of the pattern centered on the earth demands a self-oriented vehicle with earth-tracking capabilities (*Fig. 1*).

Orienting can be accomplished (without reaction motors) to a reasonable degree by using the inertial properties of rotating bodies (gyros) for reference. This is already being done in lunar probes—the components of the instrumentation and transmission systems are arranged in a ring about the longitudinal axis to form a high moment of inertia around it. This design stabilizes the vehicle in space so that, after a period of damping, the resultant motion of the body will be a rotation only about this single axis.

If you were to complement this form of stabilization with a servo-controlled directional antenna, it would be quite feasible to maintain a position in which the major portion of the radiated energy would be directed at the earth. Again, frequency and range requirements would dictate the degree of accuracy needed in the tracking mechanism. Properly oriented and tracked, such a system could provide beamwidths of 10 deg and overall gains of 25 db over the omnidirectional type of antenna.

Energy sources will be heaviest

Energy sources will probably comprise the weightiest part of the transmission system for some time to come. Presently, some 40 per cent of the instrument weight in a lunar probe is devoted to the battery—because of the high weight penalty due to the low efficiency of the conversion of chemical to electric energy.

The seriousness of this problem is apparent if we consider the energy requirements of a hypothetical Mars probe. Feasibly, communication from such a probe could be maintained with 0.1 W of power. This power should be available during the entire trip, lasting about 200 days. To get this 0.1 W, we'd need a power supply capable of putting out one watt.

Since chemical cells now in use can provide 45 W/hr per pound of battery weight, a one-pound cell could satisfy the energy requirements for two days. So we'd need a battery weighing 100 lb for the Mars exploration. Of course, this figure doesn't allow for increased energy demands to satisfy accuracy and reliability specs.

If we used solar cells instead and five per cent is taken as their conversion efficiency, the cells would have to intercept 20 W from the sun. Since solar emission provides about 1000 W/m^2, the required solar cell area would be 1/50 m^2. This area would have to be normal to the sun's emissions.

We may conclude that the use of solar cells as the energy source during a Mars exploration would be feasible if the mechanics of maintaining a collecting surface of about six inches on the side could be designed. Actually, a simple solution might be to cover the periphery of the sphere with solar cells, so that the required area would be exposed to the solar radiations regardless of the vehicle's orientation.

Both the scientific and propaganda aspects of the Mars probe experiment might best be served if the information relayed to earth were a picture of the planet's surface. Assuming that the venture's budget includes the costs of developing techniques that will increase the efficiency of data gathering and scanning and ensure that each bit of data was of prime value with no redundancies, then the entire 100 lb of chemical battery or equivalent solar cell might be devoted to providing a television picture of Mars.

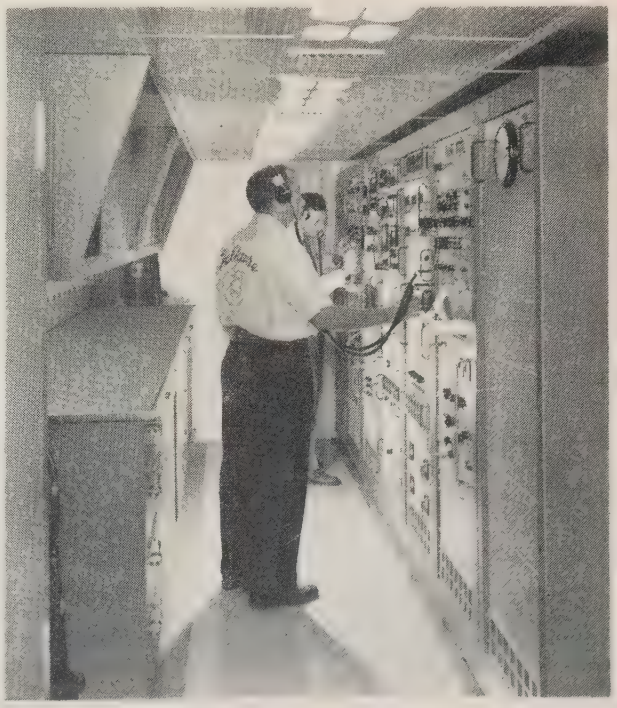
The energy source we would have then could provide 20 million bits of information at a one-bit-per-second rate. For a TV image of Mars, with four shades of gray in the tonal range, these 20 million bits would make up 5,000,000 picture elements of the surface. Since the total surface area of Mars is about 100 million sq miles, each image element will have to cover 20 sq miles.

The optical resolution needed for this picture, if the vehicle orbits Mars at 10,000 miles, is 1/20 milliradians, or about 10 seconds of arc. The problem is again complicated by the fact that, at this range, Mars would subtend only three degrees or arc. This kind of resolution is impossible to get with the type of optical equipment a probe could carry.

Therefore, the proposed probe would have to orbit much closer to Mars—no mean feat in itself. It would probably take a polar orbit around the planet to make possible the repeated passes needed to accumulate all the desired information.

We have been considering a method whereby the information bits for the TV picture would be transmitted as the surface is scanned. A more economical procedure might be to photograph the surface and then transmit the information scanned from the photo. Still another alternative would be to record the TV picture on tape and transmit the information back at a slow rate.—End

INTERIOR of Hallamore trailer housing phase-lock receiving equipment for data transmission from lunar probe.

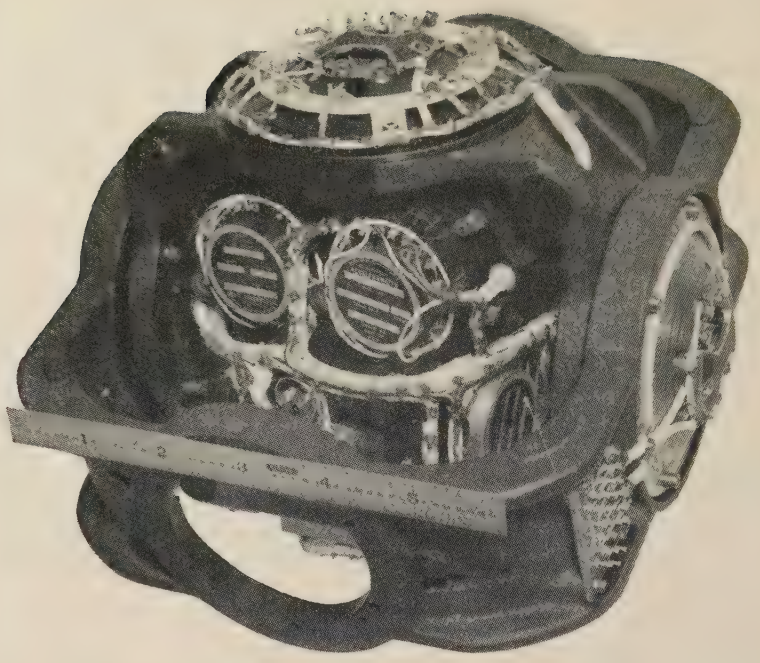


design digest

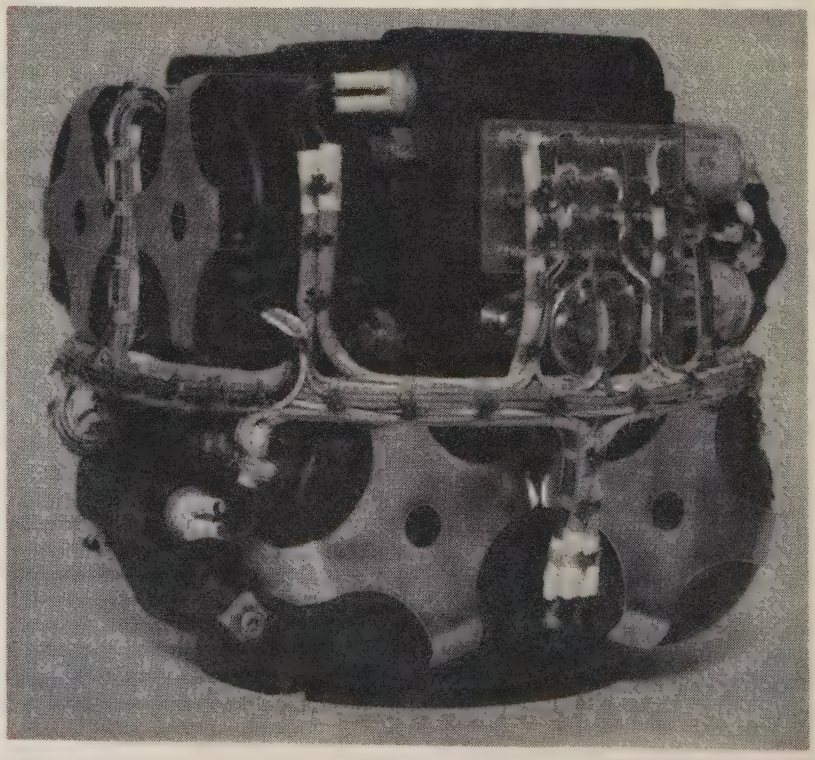
by Bernard Kovit
Associate Electronics Editor

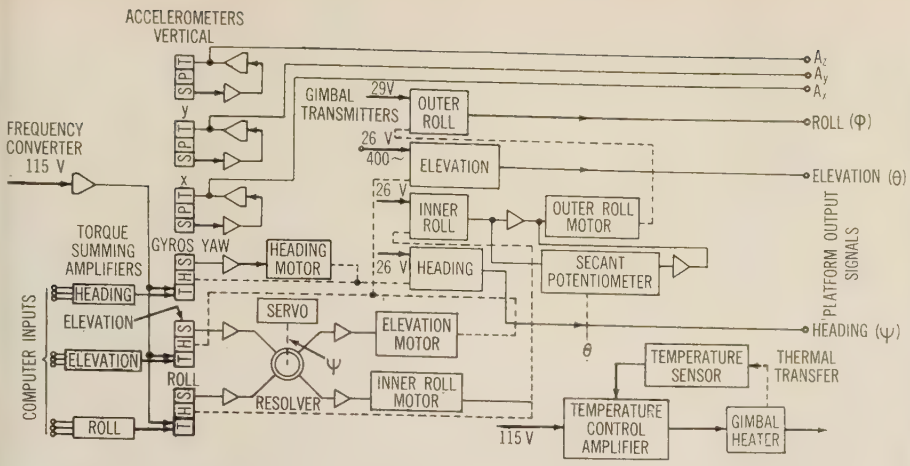
MIG platform extends inertial system use

ADVANCED versions of the MIG (*Miniature Integrating Gyro*) platform are being turned out "at production rates" at Aeronautical Div., Minneapolis-Honeywell Regulator Co., 2600 Ridgway, Minneapolis 13, Minn. An integrated device scaled to the size of tiny MIT-type floated rate gyros and pendulous accelerometers, the 28-lb, all-attitude platform and its 26-lb amplifier package form a system that attains a 0.025 deg/hr random drift rate. For inertial navigation, it is capable of 3.5 nm/hr performance. These precision characteristics and the significant weight and space savings have extended the range of applications for inertial systems in aircraft and missiles. Uses include short-term inertial navigation for aircraft and drones, midcourse guidance for surface-to-air missiles (Bomarc), vertical and heading reference for autopilots, back-up guidance and stabilization for recon vehicles, and comm satelite stabilization. Write in No. 66 on Reader Service Card for more information.

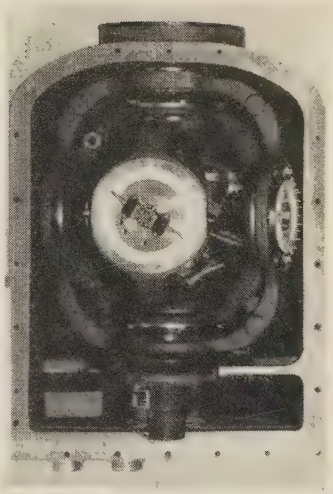


MIG PLATFORM (shown above in three-gimbal version without case) was designed from scratch as an integral unit, its overall specs governing design of the MIGs, accelerometers, and gimbals. M-H produces the miniature system in several versions—two- or three-gyro configurations with two or three accelerometers, etc. In both the three- and four-gimbal platforms, elevation and roll-gyro information is resolved according to heading angle to correct the gimbal servo motors for sharp attitude changes. A resolver on the heading gimbal (below) and a secant pot on the elevation gimbal provide secant function gain change as elevation angle (attitude) nears 90 deg. Internal heater keeps platform components at an even 180 deg F. High operating temperature eliminates weighty cooling devices. Further bulk is reduced by pairing a direct-drive, pancake synchro transmitter and a dc servo motor on all gimbals except heading, where gear-driven synchros are used. Problem of gear chatter is eased, too.

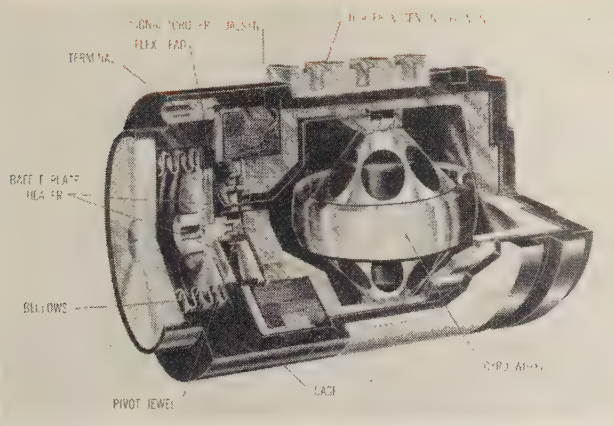




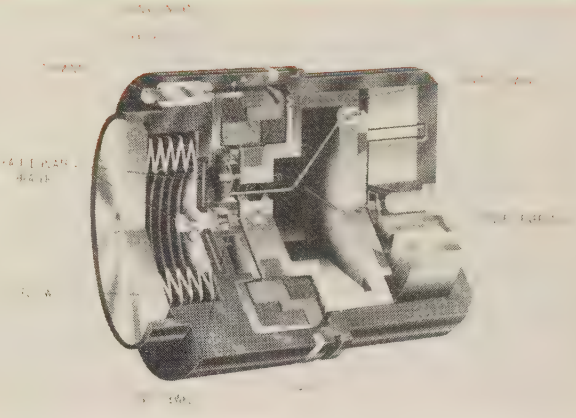
PLATFORM AND AMPLIFIER ASSEMBLY (four-gimbal version): Basic system outputs are three 400-cps signals proportional to aircraft heading, elevation, and roll, respectively, and three acceleration signals proportional to acceleration along orthogonal, horizontal, and vertical axes. Amplifier is made up of replaceable sealed modules. System operates on 115 V line neutral, 400 cps. Platform random drift is 0.025 deg/hr; fixed drift is automatically trimmed to less than 0.1 deg/hr during warmup.



FOUR-GIMBAL platform is itself an inertial system. Paired with Doppler it smoothes velocity signals, provides memory during radar signal lapses.



GYRO—Though M-H GG49 MIG gyro compares in performance with any production inertial hardware, it's about nine-tenths lighter, weighs less than eight ounces, is 2.75 in. long. Design is based on MIT (Draper) concept.



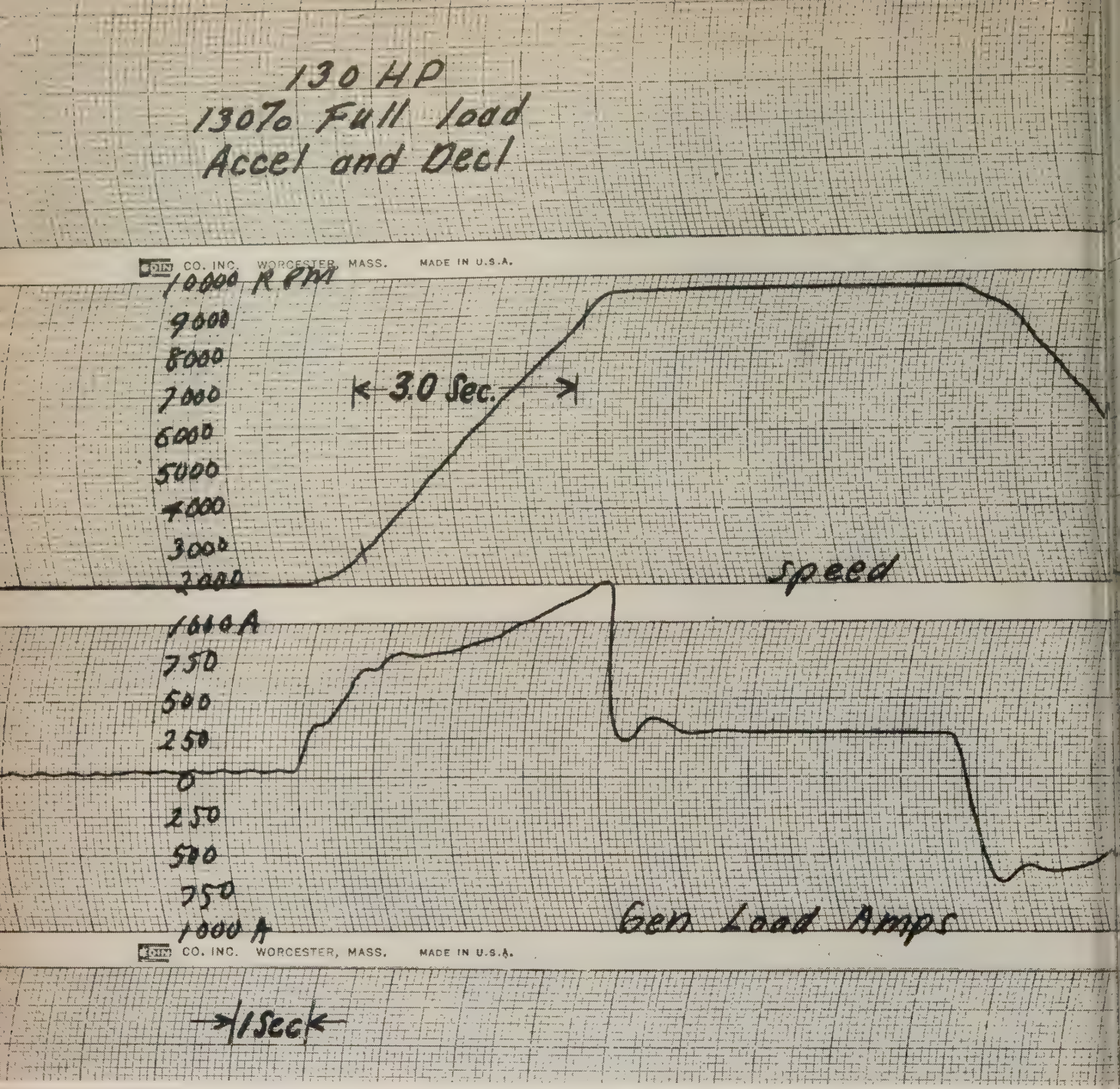
MATE TO MIG gyro is seven-ounce, 1.75-in.-diameter GG56 pendulous current-balance accelerometer. Pendulosity of mass in floated gimbal is 1000 dyne-cm. Threshold is 10^{-4} G. Certain parts are interchangeable with gyro.

MIG Stable Platform Dimensions

	Size (in.) H	W	L	Weight (lb)
Three-gimbal version				
Platform	9 (dia)		13.2	25
Amplifier assembly	9.25	8.0	12.0	23
				48
Four-gimbal version				
Platform	9.7 (dia)		13.5	28
Amplifier assembly	9.0	9.0	12.0	26
				54

Gimbal Mechanics

- Three-gimbal platform is gimbaled (from inside out): heading, elevation, and roll. Gimbal freedom of this lightweight package is 360 deg in both azimuth and roll axes and ±85 deg in elevation.
- Four-gimbal platform includes servo-driven auxiliary gimbal to provide complete freedom of maneuvering without having the platform gimbals lock. This version of the MIG platform is gimbaled (from inside out): heading, inner roll, elevation, and outer roll. All gimbals have 360 deg of freedom except for inner roll, which has ±25 deg of freedom. Outer-roll gimbal is servo-driven from a synchro transmitter of the inner-roll gimbal to keep the latter normal to the elevation gimbal under steady-state conditions.



2000 RPM/second at 130% full load...

This is the performance that the Westinghouse test stand installation at North American Aviation, Columbus, gives time after time.

Other outstanding performance characteristics of this dual 100/200 hp test installation are:

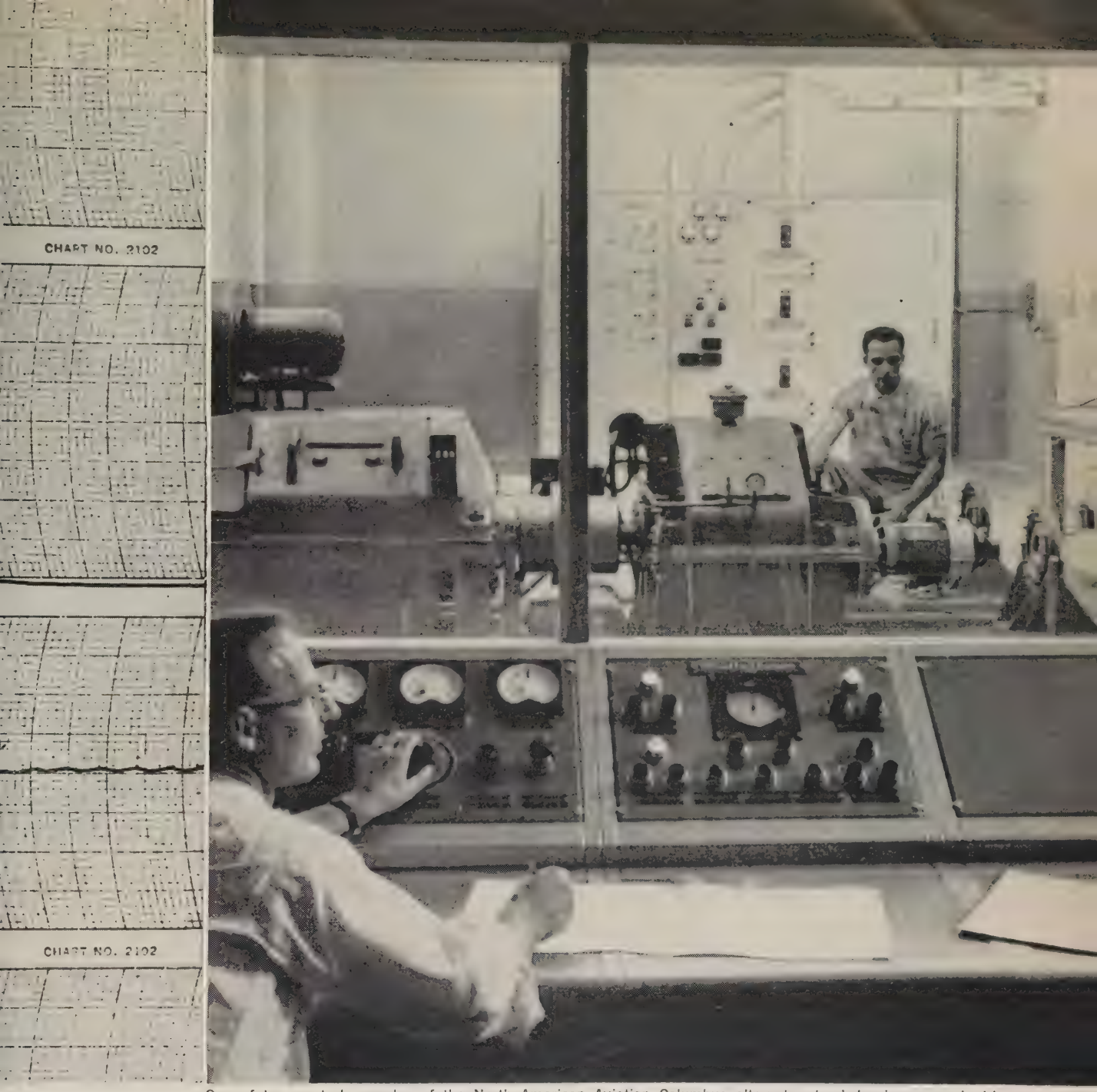
Speed adjustments: from 100 to 11,000 rpm
Speed deviation: 100% load change—not over 1%
200% load application—not over 2%
Recovery time: 200% load application — not over two seconds
Drift: ± 0.25% in eight hours
For overload testing, 150/300 hp is available for five minutes, 200/400 hp for five seconds.

Outstanding features include:

Two output gear boxes each provide 100 hp for their respective AND pads (dual or single mount).

Twin-drive systems operate independently, or they can be combined for 200 hp delivery from the gear box at either end.

For testing alternators or for complete aircraft/missile electrical systems, Westinghouse test stands permit accurate simulation and evaluation of voltage regulation, transient response, overload capacity, paralleling operations and shock loading.



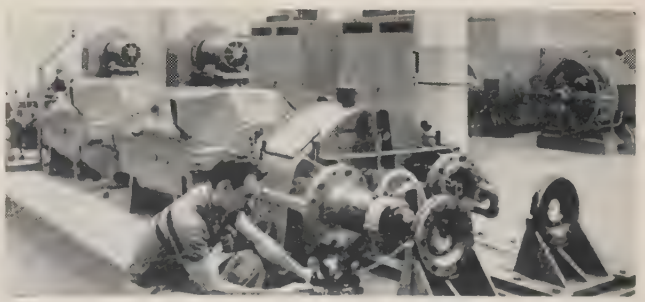
One of two control consoles of the North American Aviation, Columbus, alternator stand showing one main drive motor and speed increaser with incoming switchgear and motor control centers in background.

sing Westinghouse alternator test stands

Take advantage of this Westinghouse ability to de-
n, develop and install a guaranteed-performance unit
your production development programs for fuel
mps, alternators and complete electrical systems.
ntact your Westinghouse sales engineer or write:
stinghouse Electric Corporation, P. O. Box 868,
Gateway Center, Pittsburgh 30, Pennsylvania.

YOU CAN BE SURE...IF IT'S
Westinghouse

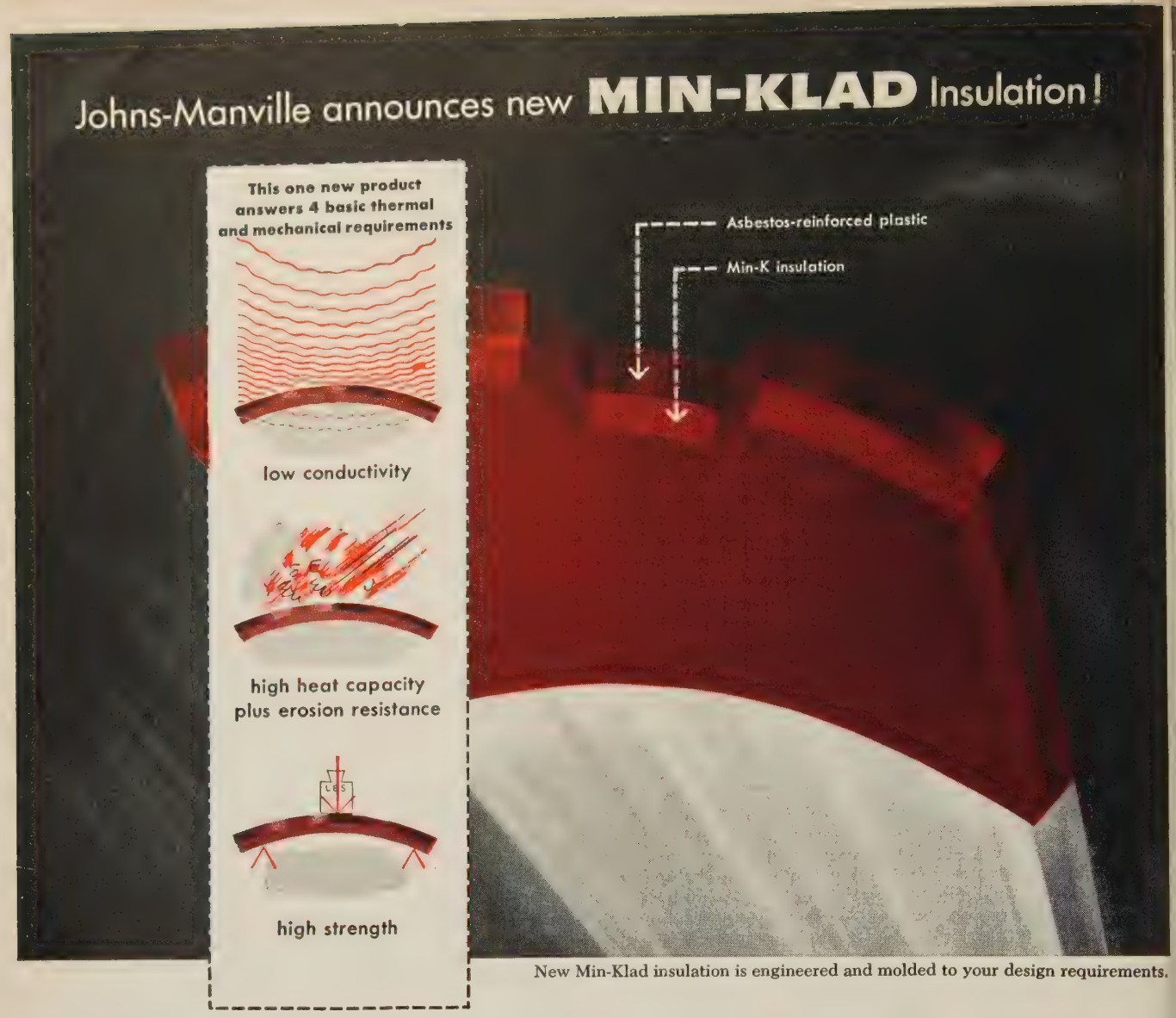
H "WESTINGHOUSE LUCILLE BALL DESI ARNAZ SHOWS" CBS TV MONDAYS



Complete dual end d-c drive showing two of four AND pads with aircraft alternator being prepared for testing. Main motor generator sets and dual test-drive control in background. J-92007

Write in No. 93 on Reader Service Card at start of Product Preview Section

Johns-Manville announces new MIN-KLAD Insulation!


This one new product answers 4 basic thermal and mechanical requirements
low conductivity
high heat capacity plus erosion resistance
high strength
Asbestos-reinforced plastic
Min-K insulation

New Min-Klad insulation is engineered and molded to your design requirements.

Combines the capabilities of asbestos-reinforced plastic with the dramatically low conductivity of MIN-K insulation!

New Min-Klad insulation may well be the most significant advance ever made in missile and rocket insulation.

Developed by Johns-Manville research scientists, Min-Klad is the only product of its kind, a permanent lamination of the missile industry's two most effective high-temperature materials: 1) reinforced plastic and 2) J-M's recently developed Min-K insulation.

Does more than plastic alone

Min-Klad gives the missile designer all the advantages of high-temperature plastic: Strength, toughness, rigidity! Erosion resistance! High heat capacity! Yet Min-Klad does more.

It also insulates . . . and with dramatic effectiveness! Its insulating element is J-M's Min-K, an insulation with thermal conductivity that is actually lower than the molecular conductivity of still air. And this conductivity (already less than half that of the best fibrous insulations) drops still further with altitude. At 10 miles, for example, it is decreased by as much as 40%, with further decreases at greater altitudes.

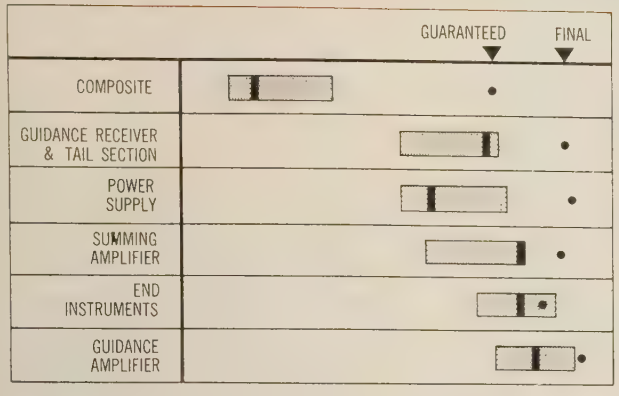
Wide range of applications

Min-Klad offers the missile and rocket designer a rich choice of heat-control possibilities. It may be used for a part that must insulate, yet have the structural advantages of plastic. Where requirements call for a scuff- and erosion-resistant insulating surface . . . or for a good adhesive bond between Min-K insulation and other surfaces. Or, it may be used to control high transient temperatures! For high heat capacity of asbestos-reinforced plastic combined with the low conductivity and heat capacity of Min-K result in a product that provides minimum heat transfer under transient conditions.

Min-Klad is now being tested for approximately two dozen missile and rocket designs. Why not investigate this new material for your present thermal requirements? Upon request, we'll be pleased to send you a sample of the material along with detailed technical information. Write Johns-Manville, Box 14, New York 16, New York. (Ask, too, for information on Min-K insulation and the new aviation insulation brochure IN-185A.) In Canada: Port Credit, Ontario.

JOHNS-MANVILLE JOHNS-MANVILLE JM PRODUCTS

Write in No. 94 on Reader Service Card at start of Product Preview Section



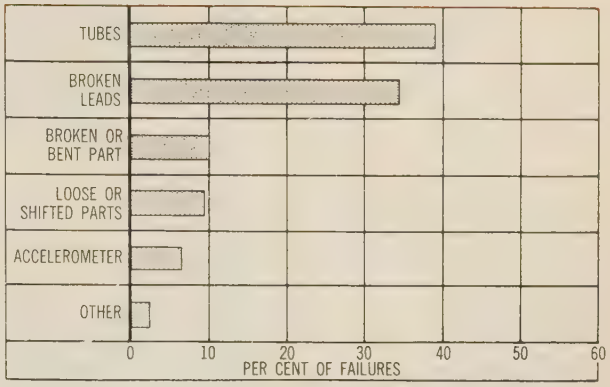


FIGURE 1: Estimated reliability under vibration before (vertical bars) and after (dots) improvement vs 95 per cent statistical confidence limits for 123 flights (horizontal bars) for various Sparrow I components (left). Guaranteed control reliability and final reliability of the production missile are also shown. Right: Percentages of total failures due to vibration effects on various Sparrow I parts.

Tests to failure boost Sparrow I reliability

Once a missile is fired it's too late to worry about reliability. The place to probe reliability is on the ground, and the best way to guard against out-of-spec causes of failures, this report argues, is tests to failure.

by E. H. Derr, Section Head, Reliability Operations, Countermeasures Div., Sperry Gyroscope Co.*

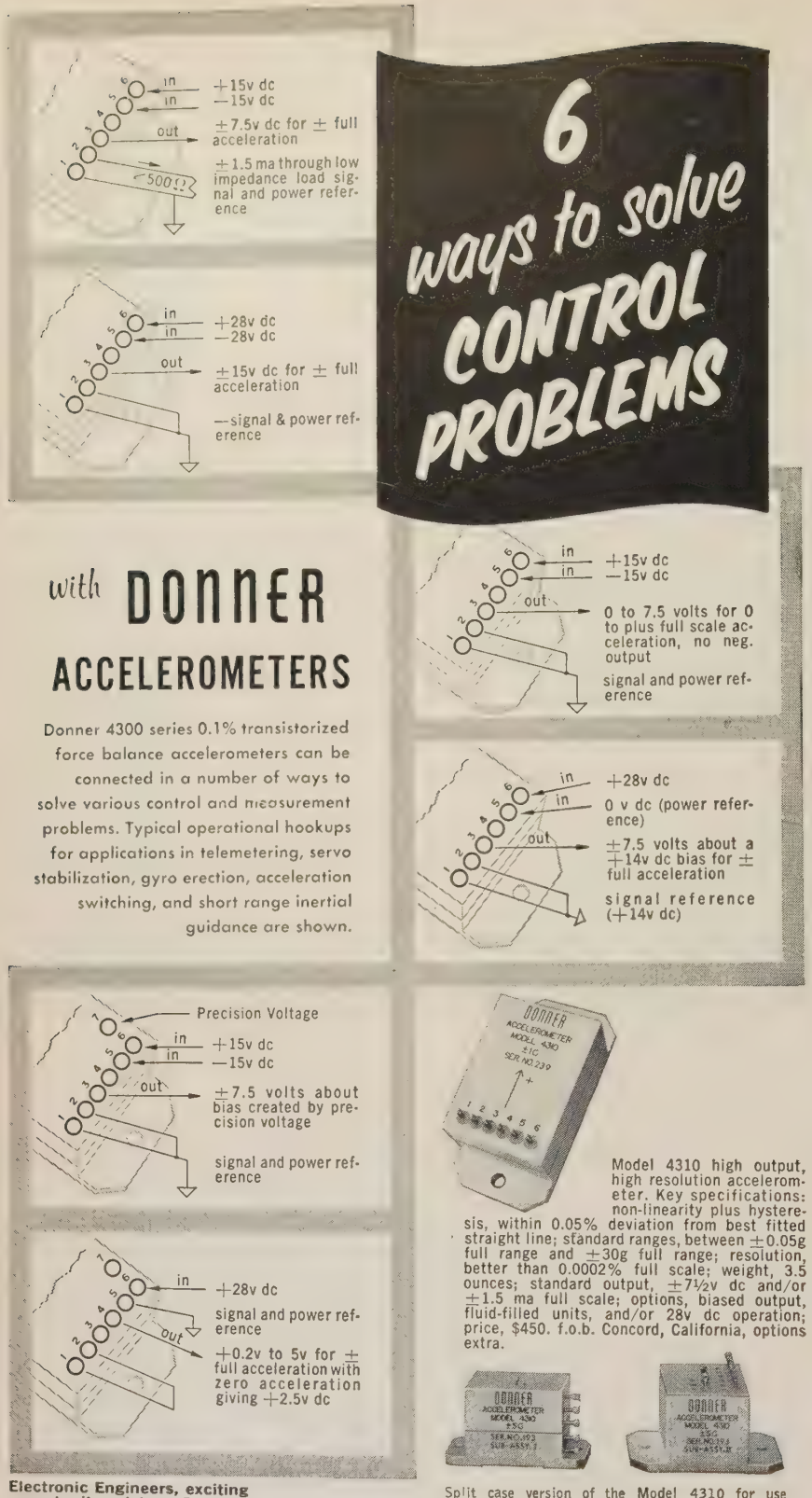
ENVIRONMENTAL tests to failure have been used for some time in the Sparrow I missile program to determine the limiting features of the design and for estimates of the improvement to be expected from remedies. The tests are performed on groups of components. Each group is exposed to environmental stresses in a sequence of identical use-cycles that are repeated until failure occurs. The unit is then repaired and the test continued until a second failure occurs.

Tests to failure differ from conventional tests in that a number of units are tested, making possible a statistical estimate of reliability. Also, though relatively small samples are tested, the results can be used to estimate the probability of failure under operating conditions that differ from those under which failures occur during test. With conventional methods, the units are tested to a fixed limit called out by a spec. This gives only go-no go type of data that actually tell us very little about the ultimate strength of the units or how they might operate in out-of-spec situations.

When we set up our program, we selected the environmental forces that seemed most likely to cause failure during use—vibra-

more on next page

* Countermeasures Div., Sperry Gyroscope Co., Great Neck, N. Y.


6
ways to solve
CONTROL
PROBLEMS
in +15v dc
in −15v dc
out ±7.5v dc for ± full acceleration
±1.5 ma through low impedance load signal and power reference
500Ω
in +28v dc
in −28v dc
out ±15v dc for ± full acceleration
−signal & power reference
in +15v dc
in −15v dc
out 0 to 7.5 volts for 0 to plus full scale acceleration, no neg. output
signal and power reference
in +28v dc
in 0 v dc (power reference)
out ±7.5 volts about a +14v dc bias for ± full acceleration
signal reference (+14v dc)
Precision Voltage
in +15v dc
in −15v dc
out ±7.5 volts about bias created by precision voltage
signal and power reference
in +28v dc
signal and power reference
out ±0.2v to 5v for ± full acceleration with zero acceleration giving +2.5v dc

with **DONNER**

ACCELEROMETERS

Donner 4300 series 0.1% transistorized force balance accelerometers can be connected in a number of ways to solve various control and measurement problems. Typical operational hookups for applications in telemetering, servo stabilization, gyro erection, acceleration switching, and short range inertial guidance are shown.

Electronic Engineers, exciting opportunity exists at Donner. Write today for full details.

Model 4310 high output, high resolution accelerometer. Key specifications: non-linearity plus hysteresis, within 0.05% deviation from best fitted straight line; standard ranges, between ±0.05g full range and ±30g full range; resolution, better than 0.0002% full scale; weight, 3.5 ounces; standard output, ±7½v dc and/or ±1.5 ma full scale; options, biased output, fluid-filled units, and/or 28v dc operation; price, $450. f.o.b. Concord, California, options extra.

Split case version of the Model 4310 for use in limited space applications; electronics on right, sensing unit on left.

Donner engineering representatives are located in principal cities. For complete technical information, call your nearby representative or write directly to Dept. 097

DONNER
SCIENTIFIC COMPANY
CONCORD, CALIFORNIA
Phone MUlberry 2-6161 • Cable "DONNER"

14

Write in No. 95 on Reader Service Card at start of Product Preivew Section

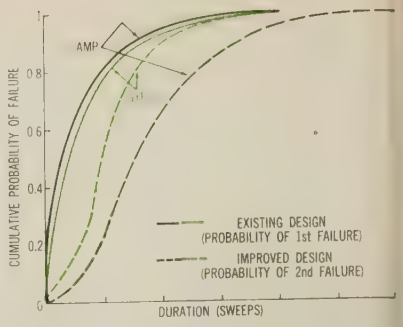


FIGURE 2: Estimated rate of failure at eight-G vibration of guidance amplifier and roll free gyro.

tion, shock, and high temperature. Sparrow I is an air-to-air missile that is guided as a beam rider during the latter part of the thrust phase and during all of the glide phase. The guidance and control system is divided into 10 major component packages, each representing a distinct functional part of the control, power, or servo systems.

The test procedure (see *Box*) consists of first establishing the characteristic use of cycle and level of intensity to be used for each separate environment. The temperature use-cycle was based on the fact that some of the most severe temperature exposures occur during factory and field systems testing. Under these conditions, the unit may be operated for long periods during which the heat dissipated within the components raises the temperature to a maximum, which is maintained as long as the unit is operated. Since a particular unit may be turned on, heated up, and turned off many times during its normal life, this procedure was adopted by us as the means by which the temperature environment is varied.

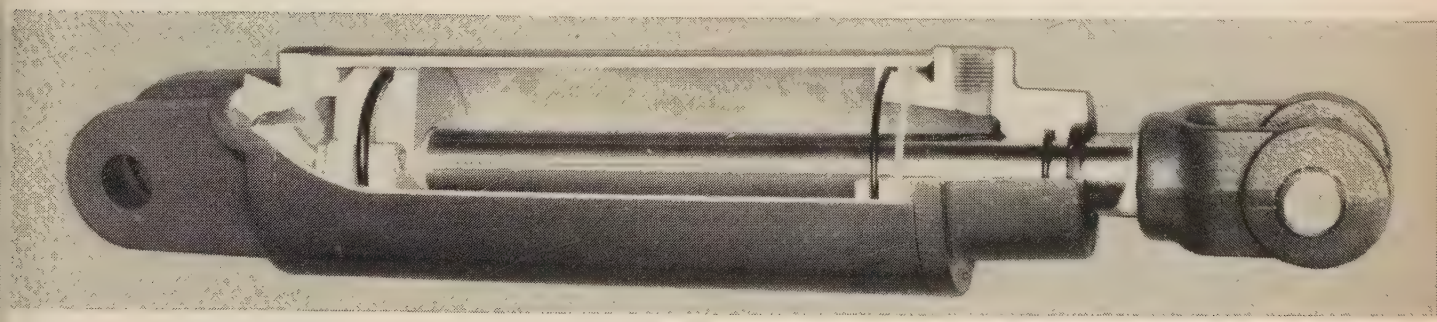
The level of intensity was selected on the basis of extensive temperature tests run with the missile operating under the extremes of temperature called for in the type-test spec. Since only one failure occurred at the specified temperature, additional tests were made at temperatures 50, 100, and even 150 deg F above it. We found that: (1) tactical use conditions don't present any significant high temperature problems, and (2) Sparrow I could actually be operated

more on page 138

There's a HOLE lot of sense in this use of mechanical tubing

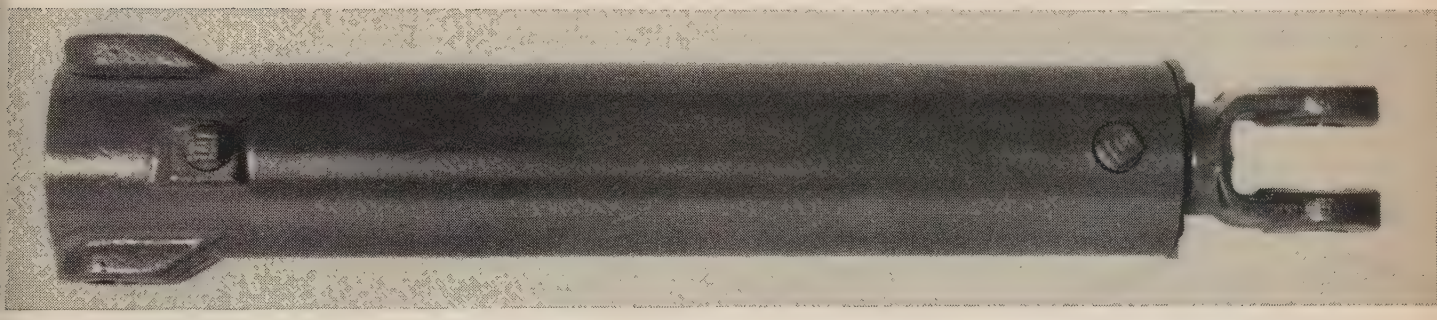
What we're talking about is USS Shelby Seamless Mechanical Tubing. Here's how Industrial Hydraulics Division, Cessna Aircraft Company uses it to boost life, simplify manufacture and lower costs in the hydraulic cylinders they supply to agricultural equipment builders. We quote from their letter to us:

"The cut-away cylinder is a unit we furnish to one of our many customers. This is a 3½" diameter, double-action cylinder used for mounting on pull-behind tools



such as plows, cultivators, and disc harrows. This cylinder uses your Shelby Seamless Mechanical Tubing with the I.D. bored to size and roller burnished to a finish of approximately six to eight RMS. The expected life of this cylinder is in excess of 300,000 cycles, operating at 1,500 psi hydraulic pressure.

"The other cylinder is furnished to another one of our customers, and is a 3¼" I.D. double-action cylinder with a 13" stroke. Used to raise and lower the platform of their self-propelled combine, it is similar to the cut-away cylinder



with respect to finish requirements and material for the barrel. The operating pressure is approximately the same and so is the expected service life of five years, or 300,000 cycles. Generally these cylinders may be serviced for additional use by merely replacing the seals.

"The severe field conditions these cylinders are subjected to are some of the most extreme to which cylinders could be exposed."

In critical mechanical applications like these, and in an almost endless number of fabrications that are essentially tubular in character, Shelby Seamless will ensure improved performance, finer appearance and economical production.

For Shelby Seamless offers more than just a pre-bored hole. It not only combines to an exceptional degree the qualities of strength, uniformity and dimensional accuracy but, in addition, is readily workable and has excellent machining properties. If you want to find out how it can be most effectively applied to your designs, contact your nearby Shelby Distributor.

And remember—USS Shelby Tubing is made by the world's largest and most experienced manufacturer of tubular products.

USS and Shelby are registered trademarks

National Tube Division of USS **United States Steel**

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors
United States Steel Supply Division • United States Steel Export Company, New York

Write in No. 104 on Reader Service Card at start of Product Preview Section

How to make a weapon

Build it around a man!

He's the most valuable 170 lbs. you can put in a modern weapon system.

If a weapon carried computers and other electronic gear with even a fraction of his capacity to sense, remember, analyze, and react—it would be so heavy you couldn't get it off the ground.

And such a weapon still would lack man's unique ability to make command decisions . . . take charge if one of the systems fails . . . respond to new orders . . . report results.

That is why the Air Force, looking far into the future, wants

system lighter...and brighter

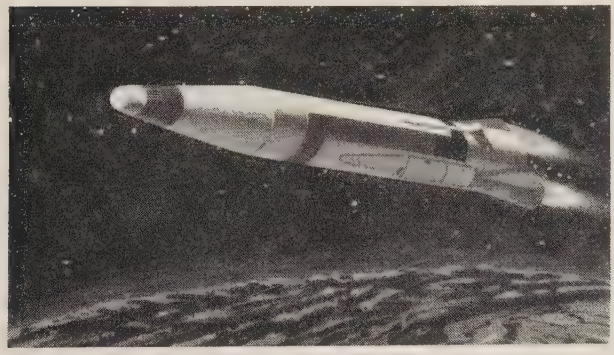
men in two of its most vital weapon systems—the B-70 bomber and the F-108 interceptor.

For though the Strategic Air Command will have squadrons of intercontinental missiles at its command, it will need the B-70 to balance its deterrent power. Aptly named the Valkyrie—for the maidens of Norse mythology who roamed the skies above the battle, deciding its outcome—the B-70 will skirt the edge of Space at 2,000 miles an hour. It will have the range to reach any target...can launch its missiles from afar at enemy ground defenses or the target itself.

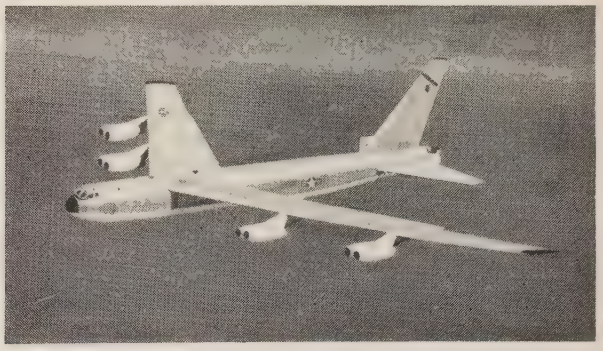
And though the Air Defense Command will have a battery of deadly counter-missiles, it will need the 2,000-mph F-108 long-range interceptor. For the enemy must also rely on manned weapon systems for precision bombing. The F-108 Rapier can meet him a thousand miles from our borders...identify him...destroy him.

North American Aviation, Inc. is weapon system contractor for the B-70 Valkyrie and the F-108 Rapier. The best qualified companies in America, large and small, are subcontractors. Work on both these vital projects is already well underway.

AMERICA NEEDS BOTH FOR A BALANCED DEFENSE



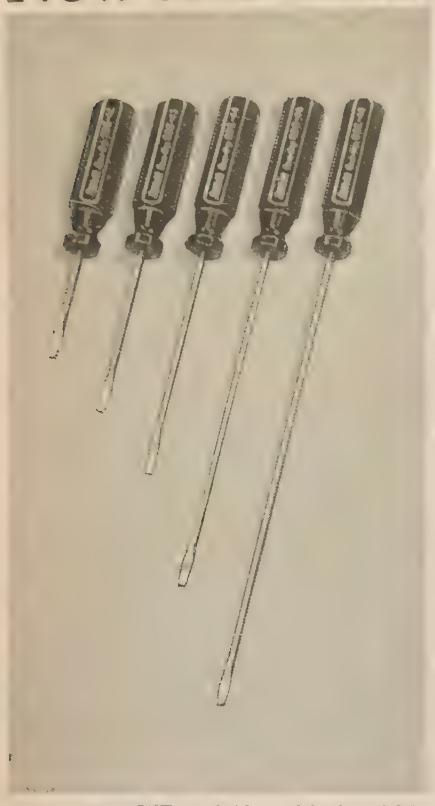
UNMANNED weapon systems—like the Atlas, America's first ICBM, and the second-generation Minuteman—will give SAC the power to reach any target on earth in 30 minutes.



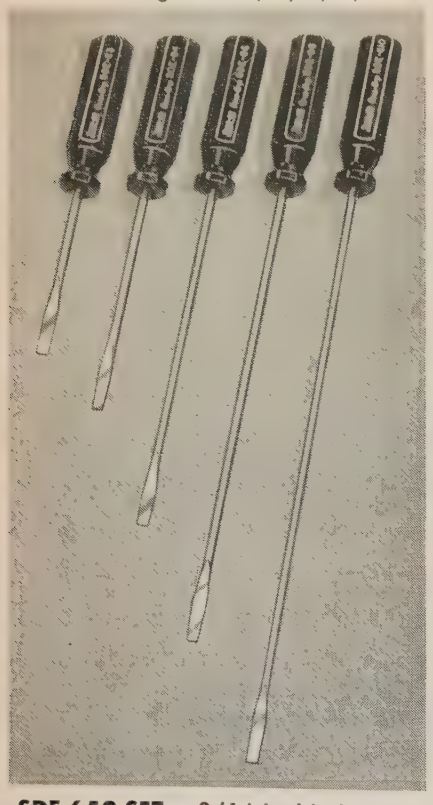
MANNED weapon systems—like SAC's B-52 bomber and its successor, the 2,000-mph B-70 *Valkyrie*—can seek out pinpoint targets... report results... and be redirected or recalled.

THE LOS ANGELES DIVISION OF **NORTH AMERICAN AVIATION, INC.**

New thin-blade screwdrivers by Snap-on speed small screw turning



SDE 450 SET — 1/8-in. blade width — shank lengths of 2, 3, 4, 6, 8 in.



SDE 650 SET—3/16-in. blade width — shank lengths of 3, 4, 6, 8, 10 in.

ELECTRICAL

ELECTRONIC

AIRCRAFT

AUTOMOTIVE

COMMUNICATIONS

ANY INTRICATE WORK

Here are real timesaving tools for electrical and electronic assembly and maintenance, or any other limited space work.

Thin driver blade tip is the same width as the shank diameter, to follow screw below surface or work among intricate assemblies. Blades are made from extra-tough alloy steel for long life. Tips are precision-machined to seat properly in screw slots to prevent slippage and damage.

Crimped shanks anchor firmly to prevent turning in handles. Two blade widths — 1/8 in. and 3/16 in. Blade lengths of from 2 in. to 10 in. Available individually or in sets of five.

Insulated handles are shockproof and practically unbreakable. "Octo-Grip" handle shape prevents tool from rolling and provides for a powerful turning grip without hurting the hand.

Put new speed in those limited space jobs with these new *Snap-on*, thin-blade screwdrivers. They'll pay for themselves in short order. Write us or call your nearest *Snap-on* branch.

SNAP-ON TOOLS
CORPORATION
8080-G 28th Avenue • Kenosha, Wisconsin

Write in No. 96 on Reader Service Card at start of Product Preview Section

Statistical Equations

Gamma Distribution:

$$f(t) = \left[\frac{1}{b^{a+1}\Gamma(a+1)}\right] t^{a} e^{-t/b}; \text{ mean: } m = b(a+1)$$

Cumulative Distribution:

$$F(t') = \int_0^{t'} f(t)\,dt; \text{ variance: } \sigma^2 = b^2(a+1)$$

Estimators:

$$\bar{t} = \frac{\Sigma t_i}{n} \sim m \; (t_i \text{ in sweeps})$$

$$s^2 = \frac{\Sigma (t_i - t)^2}{n-1} \sim \sigma^2 (n = \text{sample size})$$

Incomplete Γ-Function:

$$I(u,p) \quad \frac{\int_0^u \sqrt{p-1}\; e^{-v} v^p dv}{\Gamma(p+1)} \text{ for } \begin{cases} p \geq -1 \\ u \geq 0 \end{cases}$$

$$F(t') \text{ for } \begin{cases} p \\ t' \end{cases} \quad \begin{matrix} a \\ bu\sqrt{p-1} \end{matrix}$$

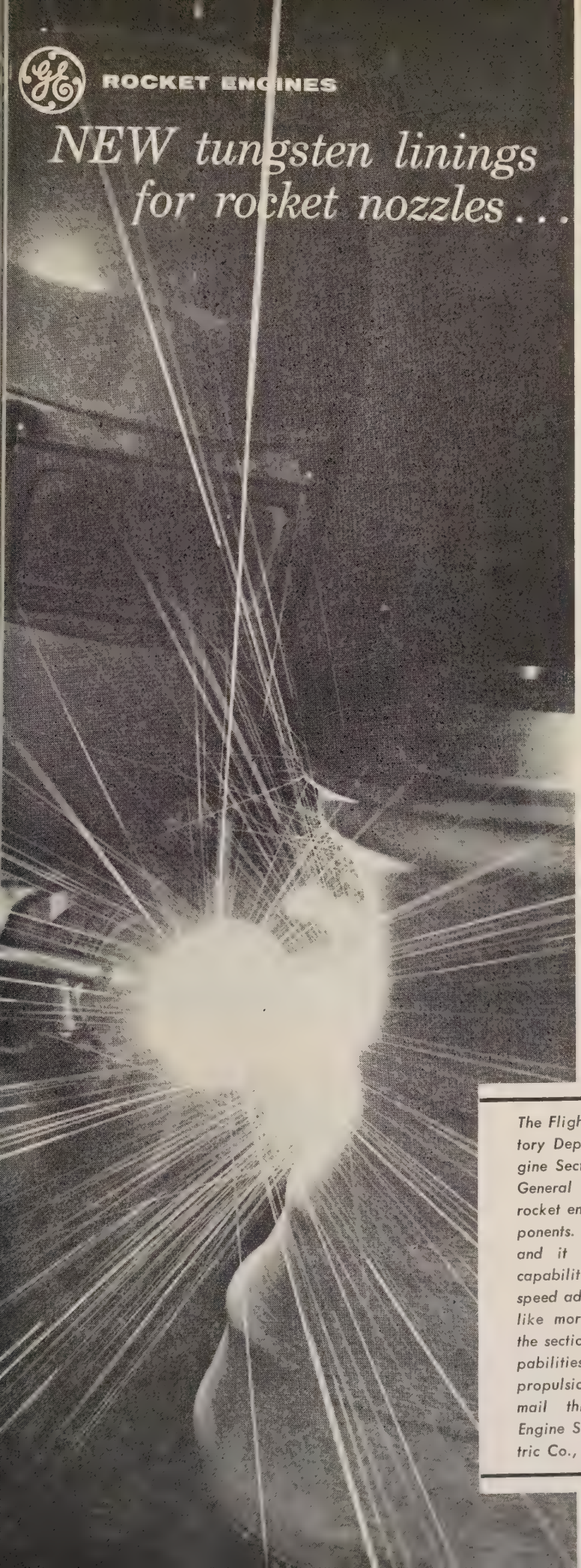
under more extreme conditions than were specified (at higher launch speeds, for example).

Using data from several sources, we set up the use cycle and the intensity of the shock environment as an impulse that starts gradually, builds up to a peak of 45 G, and drops off sharply to zero, the entire sequence lasting 35 millisec. These are conditions that are only slightly more severe than those of actual use. Two samples of each unit were tested in this manner, and only one failed after 80 repetitions. Obviously, this means a very small probability of failure due to shock.

The vibration use cycle we selected involved vibrating the unit at a constant eight-G intensity, while uniformly sweeping the frequency range from 20 to 500 cps in 10 seconds. The frequency range represented the extremes of operation of commercially available equipment at the time the tests were made. Furthermore, the small amount of data on hand about flight vibration effects showed that they were broadband in nature and below 500 cps.

Telemetered in-flight data showed an average vibration intensity of eight G. We selected the particular time period because it allowed the vibrating frequency to stay in the region of any given resonance for about 10 seconds. Though the vibration doesn't dwell on any single frequency for a prolonged period, it passes a resonant point slowly, allowing time for a build-up amplification. So in any one sweep the unit under the test is exposed to vibration whose frequency and period correspond to

more on page 141



ROCKET ENGINES

NEW tungsten linings for rocket nozzles . . .

MELTING POINT: 6170°F.

Tungsten-lined lightweight nozzles for solid propellant engines are now being fabricated by General Electric. With a lining melting point of 6170°F, these are among the highest temperature lightweight fixed and flexible nozzles in use in the missile industry, enduring high rocket propellant temperatures and pressures with no measurable erosion.

These nozzles are produced by an arc-spraying process pioneered by General Electric. Tungsten is vaporized in an arc and deposited on a mandrel. For some applications, the liner is molded in lightweight plastic, and the mandrel leached out.

Arc-sprayed nozzles have been hot-fired with the new high temperature propellants at several locations.

G.E.'s capabilities in metallurgy and manufacturing are combined with equally advanced capabilities in engineering, research and development. Integrated advanced rocket engine capabilities at General Electric can meet your needs for high performance solid propellant engine cases, nozzles and liquid engine components using cryogenic and storeable propellants.

Progress Is Our Most Important Product

GENERAL ELECTRIC

The Flight Propulsion Laboratory Department's Rocket Engine Section is the nucleus of General Electric progress in rocket engines and their components. It is well-equipped; and it uses Company-wide capabilities and experience to speed advances. If you would like more information about the section's products and capabilities in solid or liquid propulsion systems, please mail this coupon. Rocket Engine Section, General Electric Co., Cincinnati 15, Ohio.

Section G182-2
Rocket Engine Section
Flight Propulsion Laboratory Department
General Electric Company
Cincinnati 15, Ohio

Please send me additional information about General Electric solid propellant cases and nozzles (GED-3763). ☐

I would like to discuss G-E rocket engine products with a sales representative. ☐

Name .....
Title .....
Company .....
Address .....
City ..... State .....

White in No. 97 on Reader Service Card

GENERAL ELECTRIC ANNOUNCES . . .

Two new, ultra-small relays

From the company which first introduced the revolutionary micro-miniature relay in 1955 come two more important new developments in sealed-relay miniaturization.

General Electric has added the world's smallest one-amp relay, the single-pole Unimite, and a new four-pole micro-miniature to its sealed-relay line. Both new relays incorporate an important advance in relay manufacture. No solder and no solder flux are used anywhere in either relay's structure. A new inert-arc welding process seals headers to cans, eliminating a major cause of contact contamination.

The new Unimite and four-pole relays lend themselves admirably to printed-circuit-board work. The Unimite relay can be soldered into the board or is available for stud, lug, or bracket mounting. Its flexible leads can be formed or fanned for any circuit requirement. The four-pole relay terminations are on 0.2 inch centers in accord with the popular grid-spaced pattern.

These new relays, combined with a full line of miniature and double-pole micro-miniatures, offer equipment designers a new dimension in relay flexibility. Both new relays meet or exceed applicable requirements of MIL-R-5757 and MIL-R-25018.

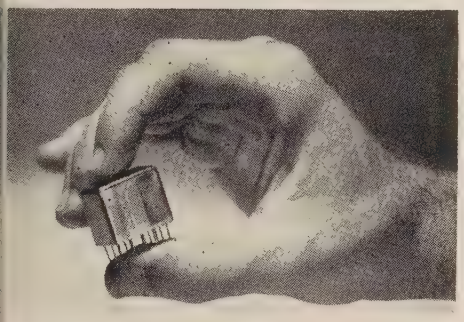
All General Electric sealed relays combine minimum size with unmatched reliability under severe shock, vibration, and temperature conditions. For complete information on G.E.'s full line of sealed relays, contact your G-E Apparatus Sales Office or mail coupon at the right. General Electric Co., Specialty Control Dept., Waynesboro, Va.

Progress Is Our Most Important Product

GENERAL ELECTRIC

Unimite is world's smallest 1-amp relay

The slim cylindrical shape of the new Unimite relay saves space in the important vertical dimension. Its high-speed operation—operates in 1.5 milliseconds max., release time 3.5 milliseconds max.—offers a new approach to automatic switching. Its welded, totally isolated contact capsule eliminates organics from switching chamber, provides lifetime freedom from contact contamination. Every Unimite is a dry-circuit relay.



4-Pole micro-miniature suited for 160C ambient

New micro-miniature provides four-pole configuration and exceptionally long life performance—minimum of 10 million low-level operations, test units have run over 50 million operations. Suitable for continuous operation in a 160C ambient, the relay provides a valuable safety factor in application to 125C equipments. Vibration performance is excellent; it withstands 55 to 2000 cycles at 30G acceleration without contact opening. Operate power is only 400 mw.

General Electric Company
Section B792-12
Schenectady, New York

Please send me a free copy of the 1959 Sealed Relay Catalog.

Name _____

Address _____

City _____

State _____

GENERAL ELECTRIC

Write in No. 98 on Reader Service Card

Tests to Failure—General Procedure

(1) Select the environmental forces or combinations likely to cause failures

(2) Find the typical use-cycle for each kind or combination of environment

(3) Subdivide the missile into packages or elements to facilitate testing and analysis

(4) Subdivide the available samples into groups and decide on the use-cycles and the intensities of environmental conditions to be used on each group

(5) Test each group of samples by subjecting it to a sequence of identical use-cycles until failure occurs

(6) As each unit under test fails, determine the cause of failure, make repairs and continue the test at the same level of intensity

the conditions of one flight.

We tested repeatedly until failure occurred. Two types of failure were closely checked: deviations from the spec and actual breakage or loss of output from a unit. To record the time of these events, the units were operated while in test. As each failed, the cause of failure was diagnosed, the unit repaired, and the test continued to the second—and sometimes to the third—failure at the same level of intensity.

A compilation of vibration failures of electronic components (*Fig. 1*) shows that two weaknesses—tubes and broken leads—accounted for 96 per cent of the failures. The mechanical components, as might be expected, show a different failure pattern, the two principal weaknesses being loose hardware and bent or broken parts. (Together, these account for 78 per cent of mechanical failures.) Failure under temperatures were due to charred and melted insulation, leaking electrolytic capacitors, burned resistors, and melted solder (in extreme cases).

In analyzing the test results, our basic objective was to find the failure probability as a function of duration and intensity of environment. By comparing this probability value with the probability of environmental conditions in actual flight you set a figure for predicting the probability of failure in flight. Some of this meaurement and comparison takes place in the testing process itself, the rest is handled in the analysis.

In the case of the high temperature and shock tests, the missile's environment was quite accurately known, so the use cycles represented one flight or preflight test reasonably well. Since, as mentioned, the results show that the probability of in-flight failure under these conditions is practically nil, detailed statistical analysis was waived.

On the other hand, the results from vibration testing clearly demanded close analysis. In this case, the intensity and other properties of the in-flight conditions were not known as accurately as in the previous cases. However, the actual reliability data on the missile were available from flight testing.

The statistical problem was, therefore, to construct curves of failure probability vs duration of vibration for each component from the tests to failure. These curves were compared with the flight reliabilities to determine the number of sweeps that could be taken as representing one flight. Finally, the curves of probability of second failure were compared with those of first failure to yield an estimate of the improvement you might expect after remedying the cause of the first failures.

As a first approximation, we assumed that the electronic packages were "collections of tubes" and that the gamma distribution fitted the packages. Statistically, it turned out the distribution did indeed fit the test results of all but one of the packages, so the gamma distribution was adopted.

The *Box* shows the statistical expressions needed to evaluate the cumulative gamma distribution. *Figure 2* shows curves of probability of first and second failure, constructed by applying the distribution to two typical packages.

We found that a duration of one-quarter of a sweep gives a probability of first failure that corresponds fairly closely with the in-flight failure rate of each component (*Fig. 1*). Though the sample tested to failure under vibration admittedly was small, it provided a sufficiently firm basis for recommending improvements.—End

AIRBORNE...NEW USAF T-38 TALON!

The T-38 Talon fills a vital requirement of the Air Training Command. It is a lightweight, low-cost aircraft in which our new generation of space age airmen can safely master the art of supersonic flight.

Pioneering a new Northrop family of economical manned aircraft for the space age, the Talon is a direct result of teamwork between Norair and suppliers. This T-38 Team that made the trainer a reality is now producing it under USAF contract at Hawthorne, California. Soon to follow is the N-156F multi-purpose fighter, American-designed for our free-world allies.

The T-38 Talon stands as the latest airborne evidence of Norair capability and production know-how. Norair's creative management further adds to the accomplishment by trimming production costs with methods that include PACE — the unique Performance And Cost Evaluation program; new and superior quality controls; and Norair-conceived, years-ahead production techniques.

NORAIR Hawthorne, California
A Division of **NORTHROP CORPORATION**

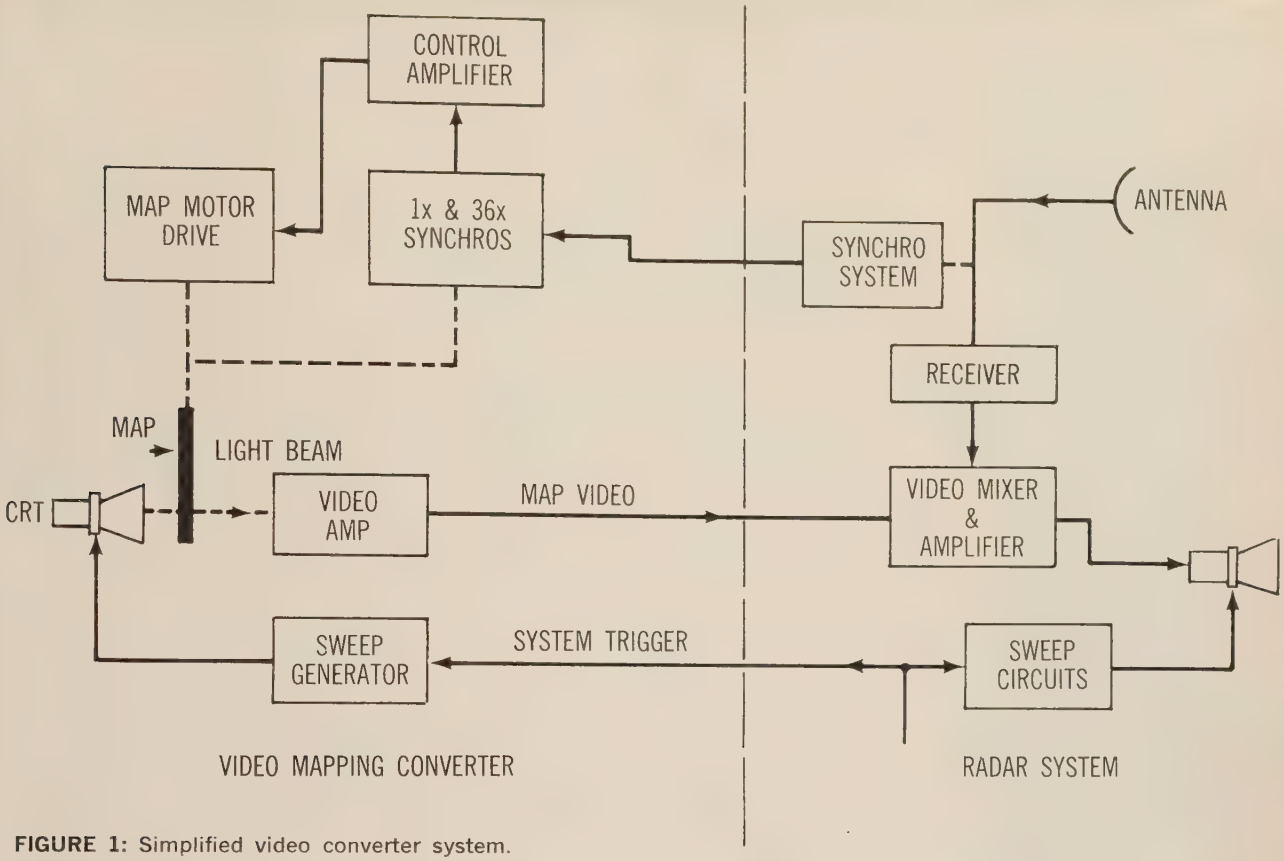


FIGURE 1: Simplified video converter system.

Video converter

puts electronic maps on radar scope

Video mapping has long been recognized as the most efficient way of superimposing the terrain and man-made features of an area on a radar display. One of the latest designs in video mapping is this converter, used with new airport search radars.

by Bruce I. McCaffrey, Manager, Manufacturing Engineering Dept., Raytheon Manufacturing Co*

IN THE design of radar for long and short range detection of aircraft, considerable effort has gone into MTI (Moving Target Indicator) circuitry. The aim has been to minimize the presence of fixed targets on the display and so get an uncluttered presentation. Of course, without fixed targets on the display from well-known ground objects, cities, lakes, prominent elevations, radio towers, etc., the operator can no longer precisely locate aircraft targets in relation to these and similar objects.

Even in systems not using MTI, the operator often wants quick identification of important ground objects. In the past, engraved plastic overlays on the plan position indicator were used for this purpose. These overlays have the obvious disadvantage of a fixed scale factor, making it necessary to change them every time the operator changes the range. As a solution to this problem, Raytheon has developed the video mapping converter, which electronically projects a map of the area on the display (*Fig. 1*).

In this converter, a cathode ray tube projects light through a film

more on next page

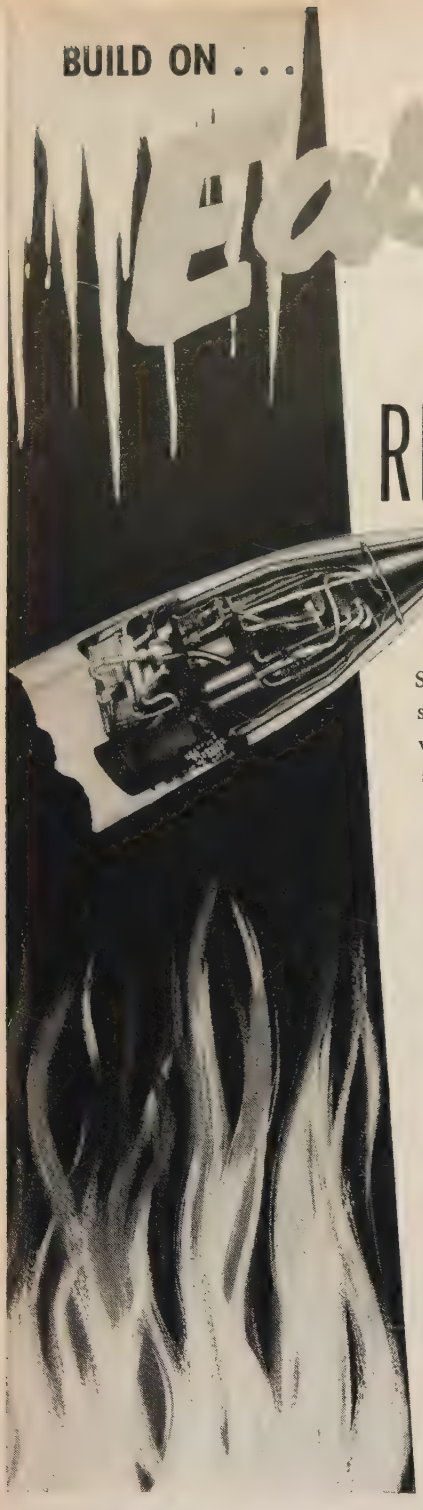
* Raytheon Manufacturng Co., 103 River St., Waltham, Mass.

BUILD ON . . .

Eastern

TEMPERATURE CONTROL EXPERIENCE

REFRIGERATION COOLING

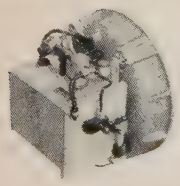


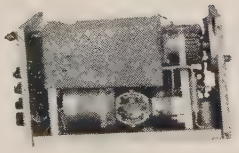
Sensitive aircraft and missile components and systems often require temperature control within close limits — while ambient temperatures fluctuate widely. Eastern refrigeration-type cooling systems are ideal for such conditions.

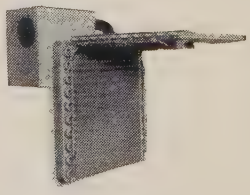
Designed for the strictest military requirements, these vapor-cycle closed-system packages are built around a highly efficient compressor powered by a special 400-cycle motor. Unique condensing and special cooling methods are called upon to meet the most unusual operating requirements, the most demanding specifications.

Capacities range from 100 to 6000 watts; operating altitudes extend to 100,000 feet. Some units, of the "boil-off" type, perform almost without regard for extremes in altitude and temperature.

Call on Eastern for imaginative solutions to *all* avionic cooling problems . . . and write for new Bulletin 360.







other refrigeration units for aircraft and missile electronics

PIONEERS OF THE THERMAL FRONTIER

EASTERN INDUSTRIES INCORPORATED
100 SKIFF STREET
HAMDEN 14, CONN.

Eastern AVIATION PRODUCTS

Write in No. 103 on Reader Service Card at start of Product Preview Section

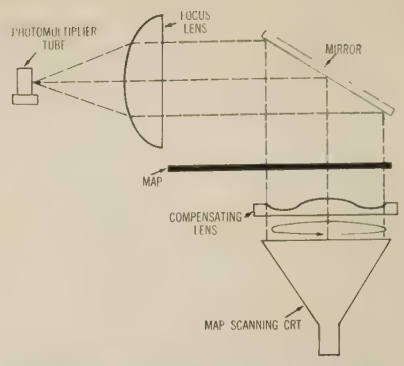


FIGURE 2: Map scanning system

negative map rotated in synchronism with the radar antenna. Light variations are produced and picked up by a photomultiplier tube and amplified. The resulting video pulses have a constant amplitude and duration proportional to the width of the transparent lines that intersect the light path. They can then be transmitted by coaxial cable or other means to radar indicators at adjacent or remote points, where they are mixed with the true radar signals to form a composite picture.

The rotation and orientation of the map is synchronized with the radar antenna (and so the PPI sweep) by a servo system that receives error signals from the antenna synchros. The video is synchronized by feeding part of the radar trigger signal to the sweep generator of the video mapping converter. Thus map detail and radar echoes can appear on one or several indicators properly synchronized and oriented.

In addition, the map retains the correct scale factor even when different range scales or expanded PPI presentations are used. The map display may be eliminated or attenuated by simple potentiometer controls independently at any PPI served by the mapping converter.

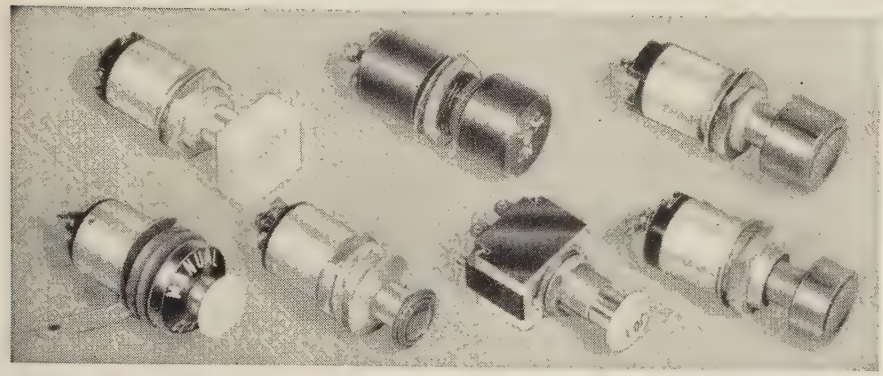
The map scanner cathode ray tube is located under the map. (*Fig. 2*). Straightline deflection bisects the face of the tube, which is positioned to scan the map on a radius from map center to map periphery. One edge of the CRT is therefore located under the center of the map. To start the sweep at this edge, the undeflected spot of one CRT must be positioned off-center. This is done by the steady-state currents in L203, con-

more on page 147

HETHERINGTON

SWITCHES • INDICATOR LIGHTS • SPECIAL ASSEMBLIES

ENGINEERING NEWS



SOLVE SPACE AND WIRING PROBLEMS with Switch/Light Combinations

You probably use these Hetherington Switch/Light combinations every time you travel via leading air lines. Here they are used as hostess call lights. As you may have suspected, however, this is just the beginning of their usefulness—both in aircraft as well as in commercial instrumentation and control uses. Their unique combination of single- or double-pole switching action together with an illuminating push button offers definite advantages in terms of greatly reduced panel space and the elimination of switch-to-light wiring. Usually the entire assembly takes no more space than a conventional switch alone.

Of particular importance for many applications, Hetherington Switch/Light combinations make it easier for operators to keep closer tabs on crowded panels without confusing control functions. By connecting the light to an externally controlled circuit the illuminated button virtually cries, *"Push Me,"* to attract the operator's attention at the right time. In other models, lamp circuits are controlled by the main switch contacts or by a second set of auxiliary contacts.

Typical contact ratings are 15 amps at 30 volts ac-dc. Illuminated buttons can be made in virtually any color, shape or size.

Write in No. 100 on Reader Service Card

HERE'S EXTRA SAFETY FOR WARNING LIGHT APPLICATIONS

JUST "PRESS TO TEST"

Ever wonder whether a warning light for a critical circuit was merely OFF or whether the bulb was burned-out?

If so, you'll appreciate the "Press-to-Test" feature of this tiny Hetherington Type L3200 light.

The lamp and its circuit can be "checked-out" simply by pressing on the spring-mounted plastic lens cap. This makes contact through a separate third terminal circuit. When cap is released, the lamp functions through the regular circuit.

The long plastic lens of the L3200 gives wide, 180-degree visibility with either standard or edge-lit panels. Uses AN3140 lamps. For more details, write for Bulletin L-2b.

Write in No. 101 on Reader Service Card

BETTER SWITCHES FOR BETTER APPLIANCES

A good electrical product deserves a good switch—and for types in the 5 to 50 ampere range that means Hetherington. Sturdy, good-looking switches —both push button, toggle, rotary, and other types—for unique operating or mounting requirements have long been a Hetherington specialty. Chances are, Hetherington switch engineers can recommend something out-of-the-ordinary that will enhance the appearance and saleability of your electrical products while assuring long, happy switch performance.

NEW PUSH BUTTON SWITCHES FOR AVIATION'S TOUGHEST JOBS . . . *Designed to MIL-S-6743 Specs*

Performance of these rugged, fully moistureproof snap-action switches far exceeds the requirements of MIL-S-6743, Drawing MS25089. They take a full 50G shock and 20G vibration, 5 to 2,000 cps, without chatter.

The basic switch can be fitted with any of eight different anodized aluminum mounting adapters, such as those illustrated, to meet virtually any mounting or design requirement.

Two-circuit, three-terminal, SPDT, and other contact arrangements are available with ratings up to 10 amps, 28 volts dc. Ask for details on Hetherington Series W100.

Similar switches for non-MIL and industrial applications are available in over 1800 different types as Hetherington Series "JR."

Write in No. 102 on Reader Service Card

HETHERINGTON INC. DELMAR DRIVE, FOLCROFT, PA. • 139 Illinois St., El Segundo, Calif.

designed for use where one failure is one too many

A Controls Company of America Subsidiary

3M COMPANY CHEMICALS

THE RAW MATERIALS OF PROGRESS

KEL-F® SEAL HELPS CRYOGENIC VALVE FEED

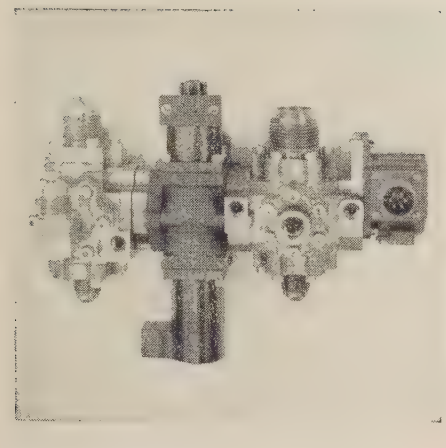
When North American's X-15 rockets out to the fringe of space, the pilot's control of the fuel metering complex will rest on Flo-Ball valves, a product of Hydromatics, Inc. Vital to the performance of the valves are precision plastic seals made of KEL-F Halofluorocarbon Polymer, a 3M Chemical. At pressures of 10,000 psi and temperatures as low as —350°F, the Flo-Ball with its seal of KEL-F Plastic opens and closes without hesitation in five milliseconds. The makers of the seals, Fluorulon Laboratories, chose KEL-F Plastic for its unequalled performance in environmental extremes. In addition to chemical and thermal stability, KEL-F Polymer exhibits zero moisture absorption, great dimensional stability, excellent electrical and mechanical properties. Check the properties at the right. Then investigate KEL-F Plastic as well as the other 3M Chemicals serving the aircraft and missiles field: KEL-F Molding Powders, Dispersions, Elastomers and Fluids, Fluorochemical inert liquids and specialty chemicals.

CHEMICAL DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

...WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY



KEL-F POLYMERS BY 3M are used to make seals for Flo-Ball valve above. Seals and other KEL-F Plastic parts, shown in inset at the left, team up with Flo-Ball for top performance.

KEL-F Plastic offers high dielectric strength: short time 1/16"—530 v/mil. Also high volume resistivity, high arc resistance. Chemical and dimensional stability: After 7 days immersion in WFNA at 90°C, weight change was only 0.3%. Wide temperature range (—350°F to +390°F) without losing useful mechanical properties. No cold flow. Can be extruded, injection or compression-molded, or machined.

FUEL TO X-15

For free literature, write on your company letterhead, specifying product interest, to 3M Chemical Division, Dept. KAO 79, St. Paul 6, Minn.

3M CHEMICAL DIVISION, MANUFACTURERS OF:
Acids • Resins • Elastomers • Plastics • Oils, Waxes and Greases • Dispersion Coatings • Functional Fluorochemicals • Inert Liquids and Surfactants

Write in No. 105 on Reader Service Card

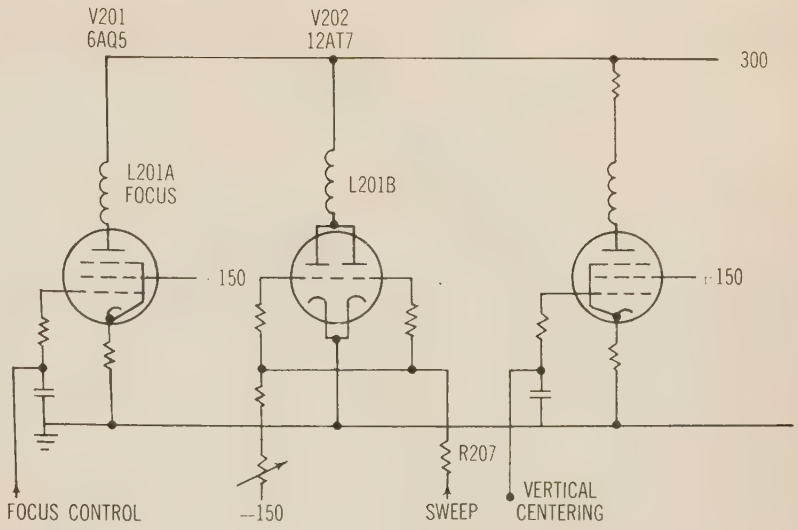


FIGURE 4: Longitudinal distortion compensation.

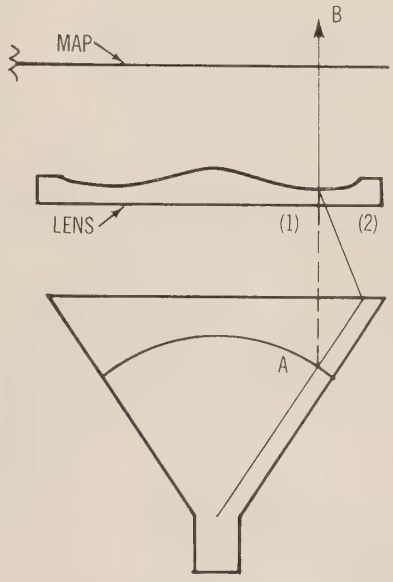


FIGURE 3: Focus and centering circuits.

trolled by the spot off centering circuit (*Fig. 7*).

The current of the off-centering control tube determines the total current through L203B, L203D, L203A, and L203C. A positive potential from vertical-centering R309 is applied to the grid of the tube, offsetting the cathode bias to position the spot under the map center. Horizontal centering is controlled by changing the ratio of current through L203A and L203D relative to the current through L203B and L203C by means of R306A and R306B, two sections of ganged potentiometer.

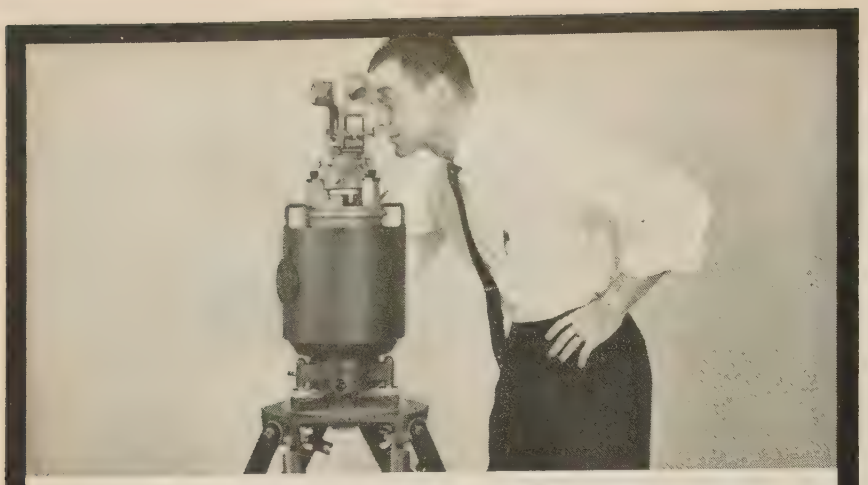
Focus coil L201 contains two windings—L201A and L201B (*Fig. 3*). Focus is obtained primarily through L201A and is determined by the V201 plate current. A focus control potentiometer furnishes a positive voltage for the control grid of V201 to offset its cathode bias. However, L201A cannot focus the spot over the entire sweep length. L201B compensates for the remaining sweep length.

The current through L201B is determined by focus-compensating tube V202, which is controlled by a portion of the sweep voltage, so that compensating current is generated during the entire sweep period. A focus compensation potentiometer adjusts the grid cutoff bias of V202, changing the portion of the sweep waveform that overcomes the cutoff bias, so that V202 conducts during the required portion of the trace.

Because of the essentially flat screen of the mapscanning 5FP-15 CRT, the light generated at the outermost portions of the straight-line sweep is "stretched" from a linear position. The stretch effect is exaggerated in *Figure 4*. When the beam is deflected to angle A, the electron beam, instead of producing light on line 1, must travel further to reach the screen. The useful light beam emerges on line 2. Compensated by the lens, light beam 2 is refracted back to its correct position and passes through the map at point B. In this way, an overall linearity of about 0.1 per cent is achieved and makes possible an extremely close correlation between radar picture and video map.

Two-speed synchro inputs 1x and 36x) are used for coarse and

more on next page



Dark or light, fair or foul...

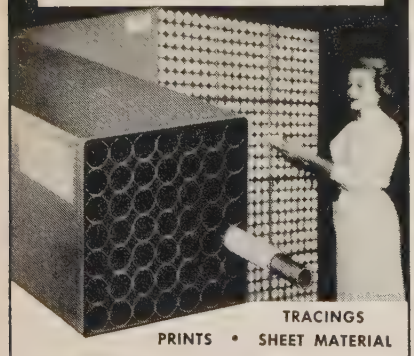
ABLE finds True North fast

Aline your missile-launchers and your mobile radars fast—with celestial accuracy—any weather, any time of day. Do it with ABLE, Autonetics' Base Line Equipment. ABLE is a portable field instrument designed to find True North or any other base line—automatically. ABLE is reliable, easy to operate and maintain. Please write for literature.

Autonetics

A Division of North American Aviation, Inc., Downey, California

MULTIROLL FILES



TRACINGS
PRINTS • SHEET MATERIAL

QUICK, FILING AND WITHDRAWAL

Depth	11¼"	22¼"	30½"	36½"	42¼"
49 Tube 1¾" I.D. MODEL	49AB $7.50	49CD $9.50	4930 $12.80	4936 $13.80	4942 $14.80
25 Tube 2¼" I.D.	25AB $7.00	25CD $9.00	2530 $11.80	2536 $12.80	2542 $13.80

Shipping Weight

Model 49	8 lbs.	12 lbs.	15 lbs.	18 lbs.	20 lbs.
Model 25	6 lbs.	10 lbs.	13 lbs.	15 lbs.	17 lbs.

ENAMELED DARK GREEN OR MED. GRAY - State Color

JR 36
Designed to Mount Under Board—Mounting Brackets Furnished. Gray Only.

9.50 SET of TWO

8 lbs. Ship. Wt.

Sold in Sets Only—2 JR36 Per Set

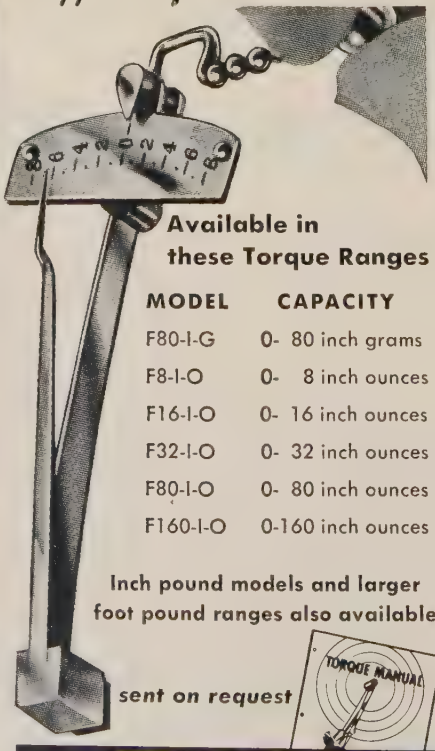
• SOLD DIRECT ONLY Write to Dept. BP •
F. O. B. St. Clair Shores, Mich. • PRescott 3-2515

ROLL & FILE SYSTEMS, INC. P. O. BOX 3863 B DETROIT 5, MICH

Write in No. 106 on Reader Service Card

TORQUE

applied by the inch ounce

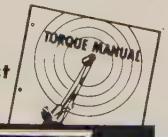


Available in these Torque Ranges

MODEL	CAPACITY
F80-I-G	0- 80 inch grams
F8-I-O	0- 8 inch ounces
F16-I-O	0- 16 inch ounces
F32-I-O	0- 32 inch ounces
F80-I-O	0- 80 inch ounces
F160-I-O	0-160 inch ounces

Inch pound models and larger foot pound ranges also available

sent on request



P.A. STURTEVANT CO.
ADDISON QUALITY ILLINOIS

Write in No. 107 on Reader Service Card

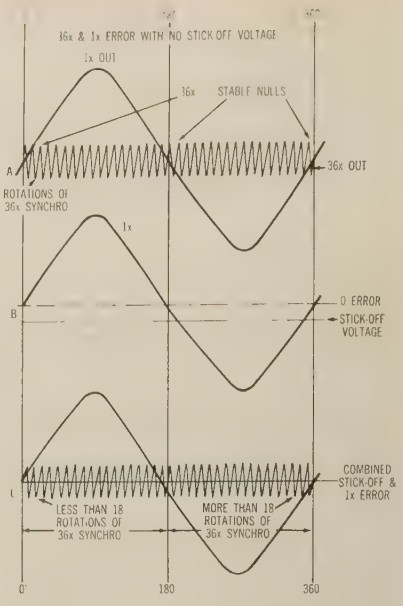


FIGURE 6: Stick-off voltage waveforms.

fine azimuthal correction during normal operation. *Figure 6* shows that both the zero and 180-deg nulls of the 1x synchro correspond to stable nulls of the 36x synchro. Normally the 36x synchro could lock on and follow a null corresponding to the 180-deg 1x system null. Therefore a (fixed) stickoff voltage is applied in series with the 1x synchro error voltage. *Figure 6* first shows three positions in which the 1x and 36x systems have zero output at the same time. It then shows a stickoff voltage relative to the 1x error signal. These voltages add, producing the asymmetrical 1x error voltage also shown in *Figure 6*. Note that the zero error signal output of the 1x and 36x systems now coincide only at zero degrees.

Sweep synchronization of the map-scanning CRT is obtained by triggering a blocking oscillator with a pulse from the radar. This pulse may be either positive or negative and may vary in amplitude from as low as 0.5 V to as high as 100 V. This is one of the versatile features intended to make the video mapping converter compatible with any radar.

The sweep circuit in the mapping converter is a phantastron. The beam of light, admitted only through transparent lines in the map, produces photomultiplier

more on page 150

Armco PH 15-7 Mo Stainless Selected for the B-70 Valkyrie and F-108

It's the primary sheet metal for construction of newest air weapon systems being developed and built by Los Angeles Division of North American Aviation, Inc.

The B-70 Valkyrie and the F-108, Mach 3 aircraft designed for 70,000 ft. altitudes, will add powerful long-range weapons to America's air armor. Both the dramatically-new intercontinental bomber and the interceptor being created by North American, in collaboration with a team of major defense firms, are to be constructed primarily of stainless steel.

Because Armco PH 15-7 Mo Stainless maintains its strength at the high temperatures caused by speeds exceeding 2000 mph, it has been specified for the major parts of the airframes.

This special stainless steel, in foil and sheets, will be fabricated into high strength, honeycomb panels for wings, fuselages, and control units. It will also be used for other key structural elements of both aircraft.

Selection of Armco PH 15-7 Mo, newest of Armco's widely used family of precipitation-hardening stainless steels, demonstrates the superiority of this high strength, heat and corrosion resistant metal. For complete information on the properties and fabrication of Armco PH 15-7 Mo Stainless Steel, write Armco Steel Corporation, 2539 Curtis Street, Middletown, Ohio.

ARMCO STEEL

Armco Division • Sheffield Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation • Southwest Steel Products

Write in No. 108 on Reader Service Card at start of Product Preview Section

a silicone resin sleeving *so flexible you can get it in spools or coils!*

- **FLEXIBLE** – may be manipulated at all temperatures, —70° to +500° F. without cracking or checking. Dielectric strength remains even when sleeving is knotted.
- **HIGH DIELECTRIC STRENGTH** – up to 7000 Volts, depending on grade. Certified to meet government specification MIL-I-3190, latest revision.
- **RADIATION RESISTANT** – retains nonconductive properties under greater-than-average random intensities.
- **WIDE RANGE OF SIZES** – .010" I.D. to 3" I.D. Larger sizes possible.
- **COLOR CODED** – available in 12 brilliant, non-fading colors.
- **CHOICE OF LENGTHS** – for the first time, continuous lengths up to 5000 feet available, thus eliminating waste. 36 inch lengths where preferred.
- **DEPENDABLE, FAST DELIVERY** – Immediate delivery on standard items from stock . . . 48 hours for new production.

Extremely useful where miniaturization increases heat and dielectric load on smaller wires, Varglas Silicone Resin "500" is only one of many sleevings made by Varflex for this type of service. If you have a special insulating problem, call on our engineers for modifications of existing products, or for developmental work to meet stringent new requirements.

● *Send for free test samples.*

Varflex SALES CO., INC.

"Never Satisfied Until You Are"

Manufacturers of Electrical Insulating Tubing and Sleeving • 316 Jay St., Rome, N.Y.

Write in No. 109 on Reader Service Card at start of Product Preview Section

Video Converter Characteristics

Power input	105-130 V, 55-65 cps, 7.5 amps
Resolution	lines 0.0025 in. wide & spaced 0.0075 in. apart will be resolved
Synchros	1-speed & 36-speed
Map turntable (radar antenna) speed	1-20 rpm
Map diameter	8 in.
Map range	10-350 nm
Trigger input	150-2000 pps, 0.5-100 V, positive or negative
Video output	positive pulses, 5 V peak, 72 ohms

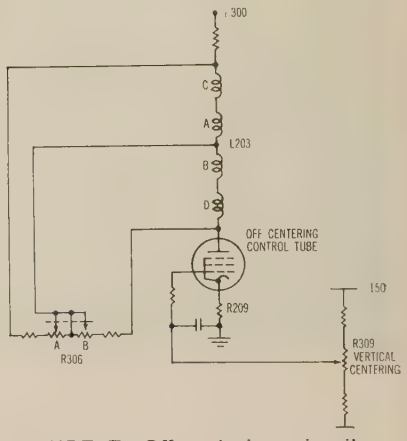
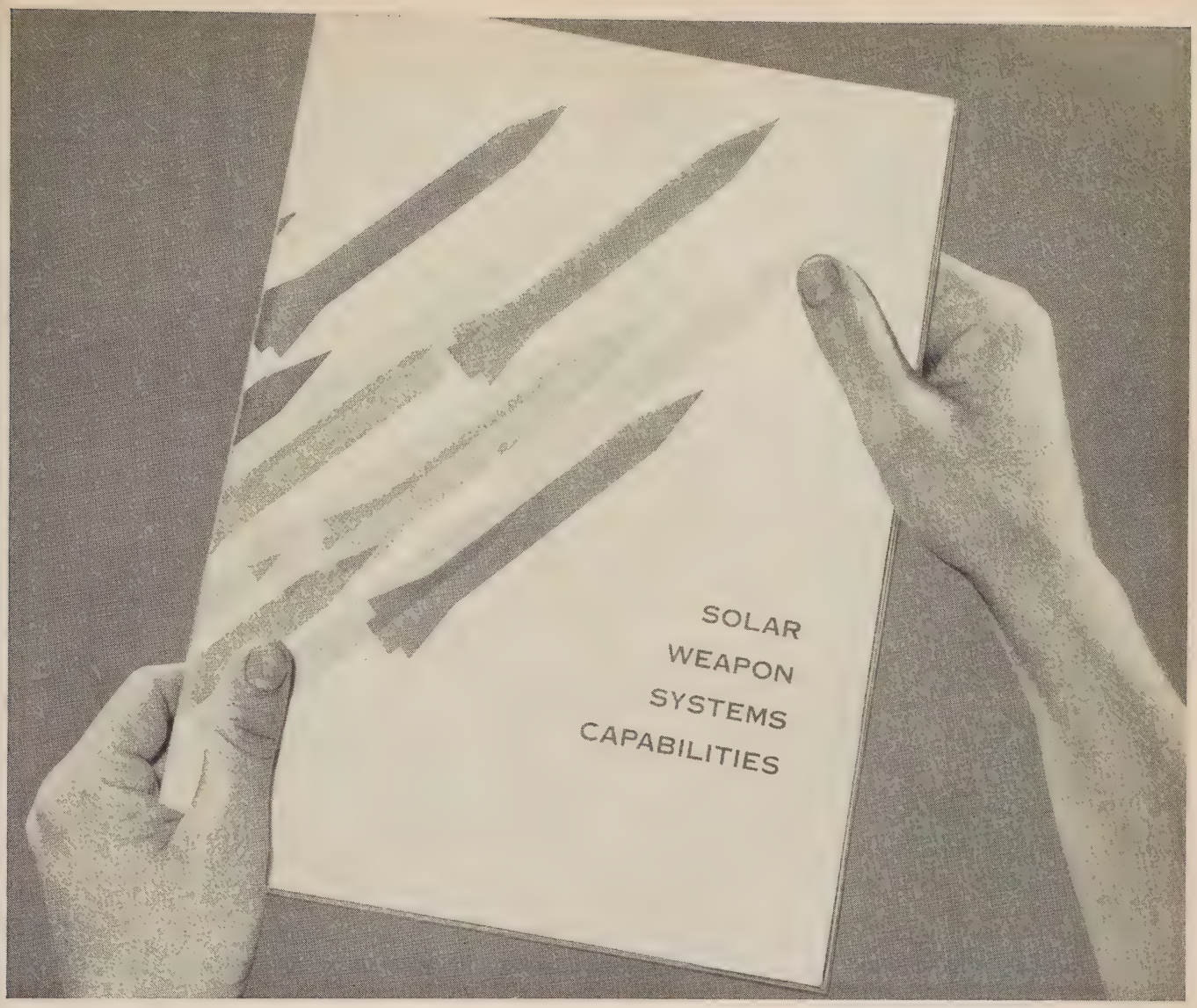


FIGURE 7: Off-centering circuit

tube current pulses that vary in intensity and duration. The instantaneous "quantity" of light admitted depends on the instantaneous area of the map lines through which it passes. Thus the photomultiplier output varies in amplitude as well as duration.

The video mapping converter must deliver pulses of constant amplitude for good map presentation. (Only the duration may vary.) Therefore the video signal is converted to square pulses that require a wide bandpass for high fidelity and resolution. The wide bandpass is gotten by direct coupling and the use of well-known techniques such as peaking coil circuits.

To date the video-mapping converter has been used as an auxiliary device to provide reference information with search radar. Circle No. 64 on Reader Service Card for more information.—End



Send for this important new brochure!

Learn how Solar's far-sighted weapon systems team and advanced facilities can step up your program

SOLAR'S WEAPON SYSTEMS capability combines more than three decades of research and development leadership in aircraft and missile technology, with complete manufacturing and test facilities. Responsibility for Solar's advanced systems program is centered in a team of experts experienced in the many phases of systems development—from conception to prototype and volume production. This closely-knit engineering and scientific team is made up of the best engineering talent available today. Collective experience of the team includes work on every major missile program! Solar is continually exploring new scientific frontiers that will contribute to tomorrow's systems technology.

A new 16-page brochure describes in detail the men and the machines that make up Solar's advanced weapon systems capability. Write for it today and learn how Solar can step up your important program. Dept. G-126, Solar Aircraft Company, San Diego 12, Calif.

SOLAR
AIRCRAFT COMPANY
SAN DIEGO
DES MOINES

For Systems Capabilities brochure mail to:

DEPT. G-126, SOLAR AIRCRAFT COMPANY
SAN DIEGO 12, CALIFORNIA

NAME_____

TITLE_____

FIRM_____

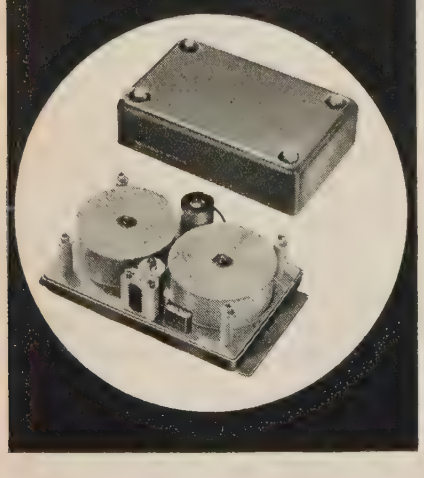
ADDRESS_____

CITY_____

ENGINEERS WANTED! *Challenging projects, unlimited opportunities with Solar. Write today!*

Write in No. 99 on Reader Service Card at start of Product Preview Section

NEW!
BEATTIE-COLEMAN
PROGRAMER
...provides
42
HOUR
PROGRAM
on 13 channels



160 feet of punched Mylar tape is accommodated in the new Beattie-Coleman MLPR-13 Programer, providing a completely random program of 2⅓ minutes duration on 13 channels. Extremely accurate time control with no cumulative error. Available in five speeds: 3/16", 3/8", 3/4", 1½", and 3" per sec. Weighs less than 5 lbs., is easily removable for loading. Programs can be initiated or altered in a few minutes. Compatible with most missile guidance systems.

Write for complete data on the MLPR-13 and other multi-channel Beattie-Coleman Programers for either repeat cycling or random operation.

BEATTIE-COLEMAN inc.
1000 N. Olive St., Anaheim, California
437 Fifth Avenue, New York, New York
Write in No. 113 on Reader Service Card

electronics scanner

OPERATIONAL air-search Navy shipboard radar in P-band (225-390 mc) reaches out 250 miles against aircraft and missile targets with "no sweat". Reflection coefficient off the water for a radar of this frequency is about unity. For L-band, it is around 0.6.

IS THE frequency spectrum a vanishing national resource? Look for a concentrated effort by industry groups for a wholesale overhaul of the apportionment of the electromagnetic spectrum. Practically every part of the spectrum up to the K-band is taken up with either useful or spurious radiations.

International frequency allocations stop at 10.5 kmc. Nationally, we allocate up to 40 kmc. At the next international radio conference (which will start in Geneva, Switzerland, in August) there probably will be a general redistribution of allocations above 50 mc, according to FCC spokesmen. The U. S. delegation is expected to propose international frequency allocation up to 40 kmc.

FCC now has regulatory powers over radiations of all Hertzian waves, with no upper frequency limit. Vastly undermanned, it does yeoman service despite pressures from domestic and international groups.

MOLECULAR engineering courses are being set up at both Stanford U. and MIT as part of the regular EE curriculum. USAF's Institute of Technology (at Wright-Patterson AFB, Ohio) is also thinking of starting such a course.

MIT, it is believed, will use as a text "Molecular Engineering," by Prof. A. R. Von Hippel (published by University Press, Cambridge, Mass.).

IT ISN'T known too widely, but quite a bit of the electronics installed in our fighters and bombers is no more useful than lead weights on many flights. Close-to-the-scene observers estimate that at least 20 per cent of the electronics carried per flight is inoperable either because of malfunctions or because the pilot or crew is not checked out in the proper use of the equipment.

All the malfunctions, unfortunately, don't show up on squadron reports, because they would make commanders look bad. Instead, much of the inoperable equipment is reported "in service" to higher headquarters. As a result specialists are having serious trouble in evaluating the mantenance problem.

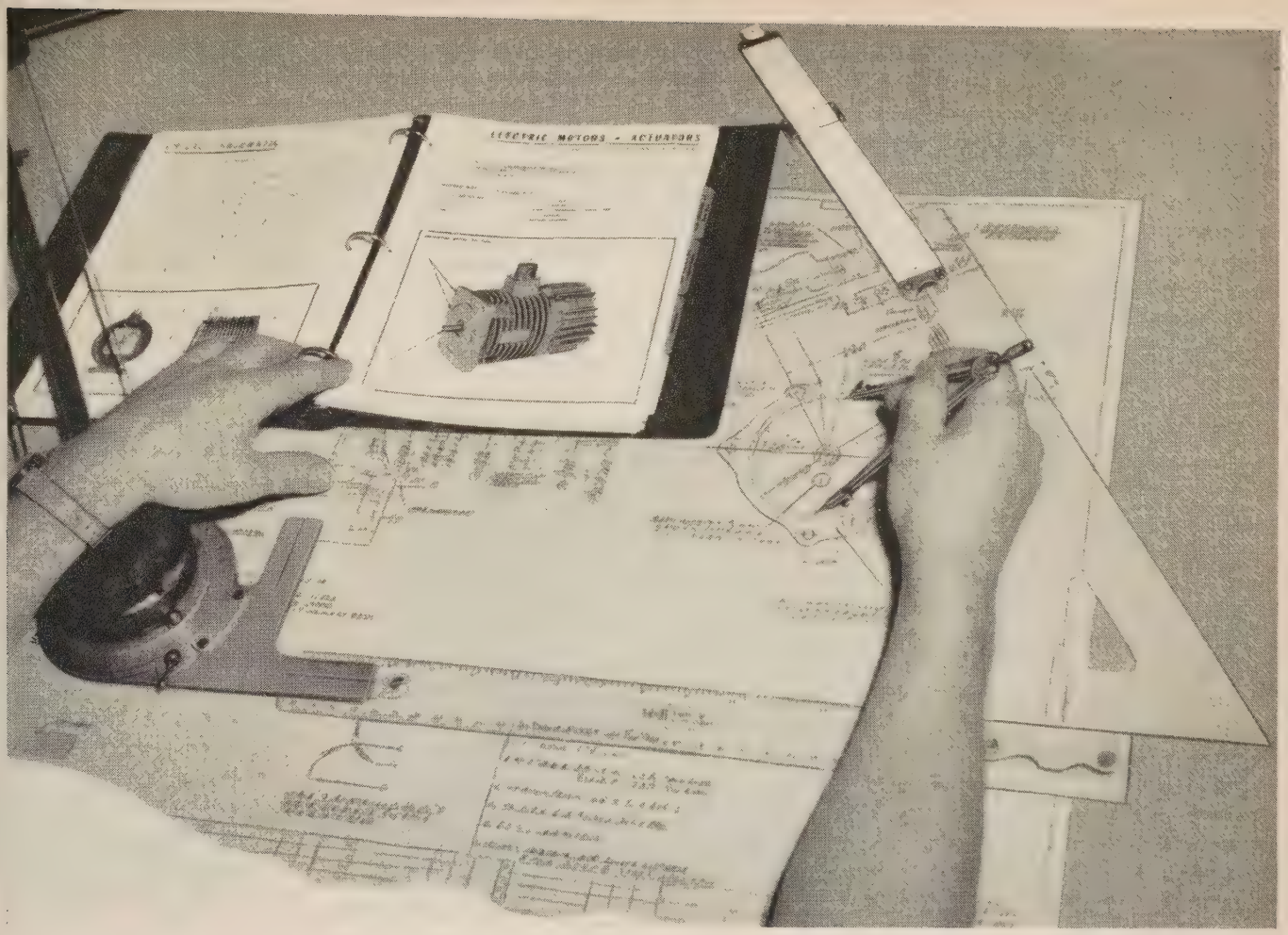
PREDICTION of the failure rate directly from the schematic of the electronic equipment is the goal of a current Arinc Research study program. Each equipment would be assigned a reliability figure, on the basis of which the supply of spaces could be estimated. The process, says the research group, could be mechanized with an IBM computer.

NEGATIVE-MASS concept is being studied by some researchers under USAF contract as a possible key to speeds higher than that of light.

RETENTION RATE of electronic technical officers in USAF is only about two per cent. The other 98 per cent leave the service after they have served the hitch they signed up for. USAF is going to have to come up with some premium-pay plan if it expects to get and keep technically qualified officers.

ONLY ABOUT five per cent of USAF's electronic components will have to operate in ambients higher than 125 deg C, according to Col. C. H. Lewis, ARDC's director of electronics. A high temperature scare a few years ago, he pointed out, led many firms to believe that very high temperature components would be needed on all electronics.

USAF, however, still has goals of 200, 500 and 1000 dg C for certain components.



If your projects include

FRACTIONAL OR INTEGRAL HORSEPOWER MOTORS

you need this book

Every engineer whose problems involve the use of 400 cycle high frequency ac, and low voltage dc motors—or 400 cycle actuators, either rotary or linear, should have this book.

Chicago Pneumatic has packed into a loose-leaf 8½" x 11" binder, 140 pages of solid specification data including photo, description, performance curves and dimensions for more than 150 specialized motors and 23 basic actuators.

Whether your work involves aircraft, missile, spacecraft, military or industrial products this book can help you solve complex power problems. Motor units, partial motors, submerged, totally-enclosed, geared and brake motors as well as actuators are included. Use the convenient coupon, today. New data will be sent direct as released. Chicago Pneumatic Tool Company, 8 East 44th Street, New York 17, N. Y.

Chicago Pneumatic Tool Company, Dept. EM1
8 East 44th Street, New York 17, N. Y.

Please send me a copy of your new book "Electric Motors and Actuators" for aircraft, missile, spacecraft, military, and industrial products.

Name_____

Title _____

Company _____

Address _____

City_____ Zone____ State_____

Chicago Pneumatic

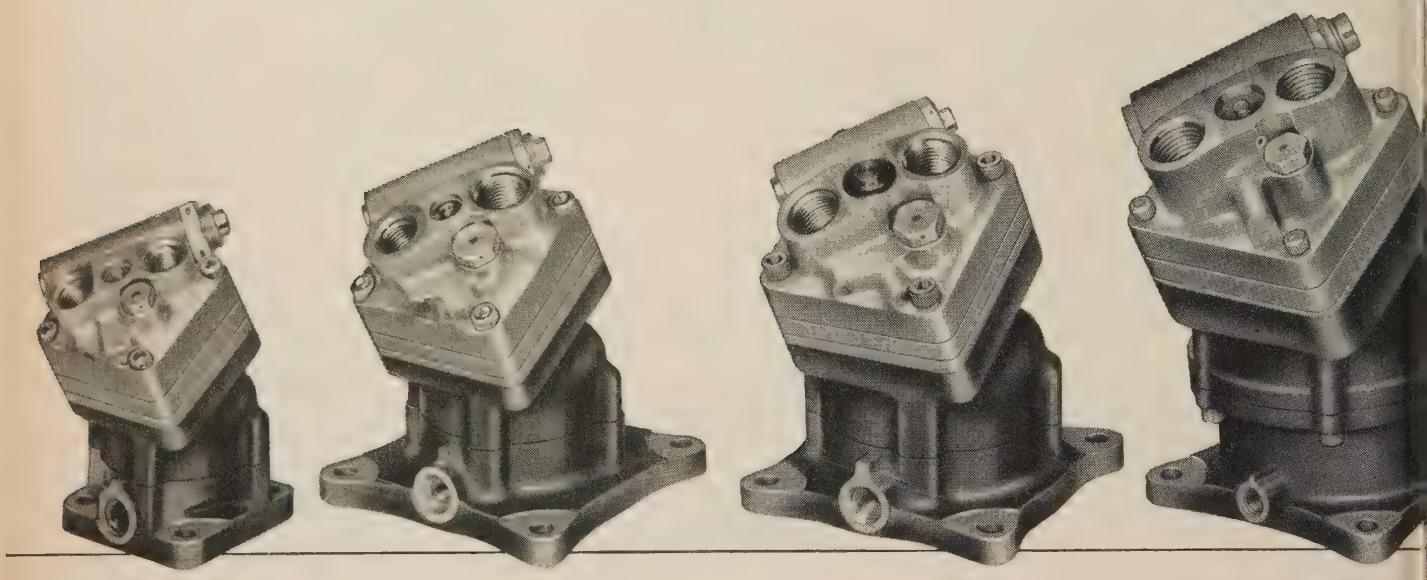
AVIATION ACCESSORIES • PNEUMATIC TOOLS • ELECTRIC TOOLS
DIESEL ENGINES • ROCK DRILLS • HYDRAULIC TOOLS • VACUUM PUMPS

Write in No. 110 on Reader Service Card at start of Product Preview Section

Design breakthrough no

VICKERS® ADVANCED DESIG

(PV SERIES)



Model Series	PV006
Theoretical Dspl.	.095 cu in./rev
Rated Speed	12,500 rpm
Weight	2.4 lb
Hp/lb @ Rated Speed	3.8
Bolt Spacing	1.875″
Overall Length	4⅜″

Model Series	PV012
Theoretical Dspl.	.188 cu in./rev
Rated Speed	10,000 rpm
Weight	4.2 lb
Hp lb @ Rated Speed	3.4
Bolt Spacing	3.536″
Overall Length	5 7/32″

Model Series	PV024
Theoretical Dspl.	.367 cu in./rev
Rated Speed	8,000 rpm.
Weight	5.9 lb
Hp/lb @ Rated Speed	3.8
Bolt Spacing	3.536″
Overall Length	5⅞″

Model Series	
Theoretical Dspl.	.600 cu
Rated Speed	8,0
Weight	
Hp/lb @ Rated Speed	
Bolt Spacing	
Overall Length	

• "Design breakthrough" as used on this page is a carefully considered statement. Here is the lineup of the PV series fixed angle variable displacement hydraulic pumps for aircraft and missiles systems optimization. The numerous important improvements briefly discussed at the right indicate that these advanced design pumps are destined to set new standards of performance.

All series have integral automatic pressure compensator and a broad range of control methods. This advanced design requires substantially fewer parts than conventional design . . . and it has reduced to a minimum the number of external sealing elements. Now, for the first time, the power saving (and heat rejection) advantages of variable displacement are available in pumps of fixed displacement envelope and weight.

When first announced last March, only the smallest unit (Series PV006) had completed exhaustive endurance tests and was available. Now three more series (PV012, PV024 and PV039) are ready for system application. Three larger sizes are in the development stage. *For further information write for Bulletin A-5233.*

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
Aero Hydraulics Division • Engineering, Sales and Service Offices:
ADMINISTRATIVE & ENGINEERING CENTER
Department 1481 • Detroit 32, Michigan
TORRANCE, CALIFORNIA • 3201 Lomita Boulevard
P.O. Box 2003 • Torrance, California
Aero Hydraulics Division District Sales and Service Offices
Albertson, Long Island, N.Y. • Arlington, Texas
Seattle 4, Washington • Washington 5, D.C.
Additional Service Facilities at: Miami Springs, Fla.

IMPROVED LIFE

Exhaustive endurance tests have proved t new pumps meet the requirement of MIL-P-19692 specification (i.e., 750 hour rated rpm which is a very substantial incr over the 560 hours previously required).

INCREASED SPEED CAPABILITIES

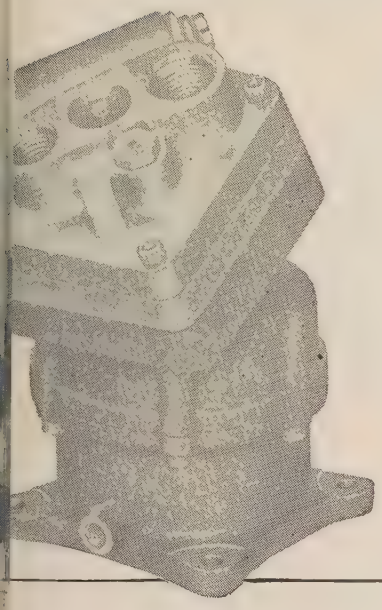
The maximum recommended speeds (b continuous and intermittent) have been gre increased for all sizes without exception more than doubled for some models.

SAME HIGH EFFICIENCY

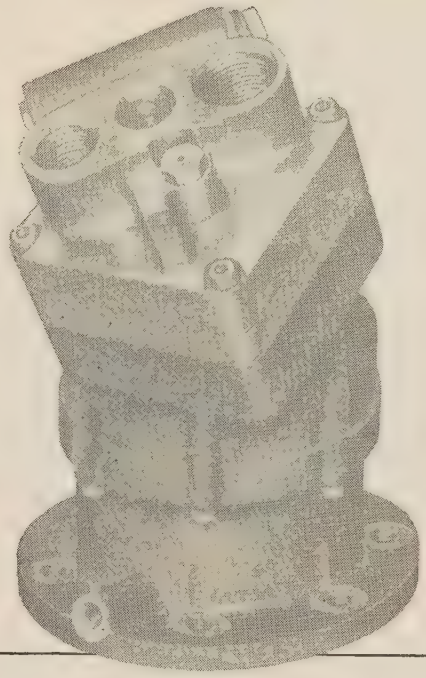
Volumetric efficiency is from 96% to 98% a pressure range of 500 to 3000 psi. All improvements enumerated here have b made without any sacrifice of the exceptio high efficiency inherent in Vickers axial pi type pumps . . . under partial as well as flow conditions.

depth!

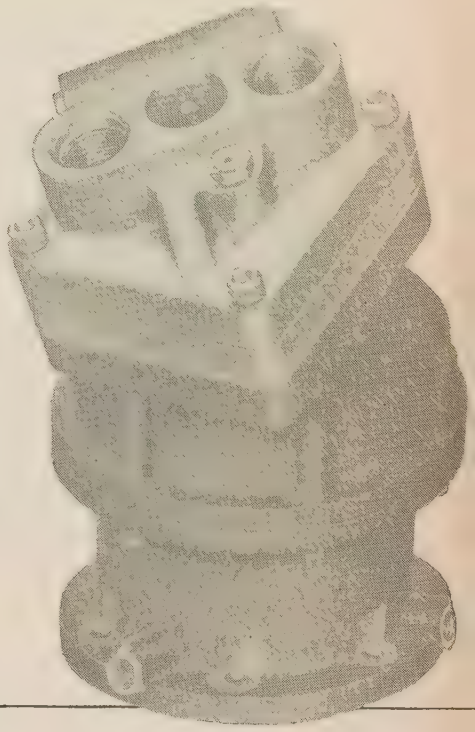
ARIABLE DISPLACEMENT PUMPS



Model Series.....PV062
Theoretical Dspl. .950 cu in./rev
*



Model Series.....PV104
Theoretical Dspl. 1.600 cu in./rev
*



Model Series. . . PV153
Theoretical Dspl. 2.350 cu in./rev
*

**Similar inherent performance advancements shown for the smaller pump sizes will be carried over to these models.*

IMPROVED RESPONSE

The PV006 series is capable of full flow to zero flow response in 0.02 sec and zero flow to full flow response in 0.04 sec without pressure oscillation.

MINIMUM PACKAGE

These PV series variable displacement pumps have practically the same envelope as constant displacement units of equal output. In comparison with standard variable pumps, the reduction in envelope varies from 70% to 15% as size increases.

IMPROVED CONTAMINATION RESISTANCE

Performance of these new pumps is greatly improved even when operating with contaminated oil. This improved contamination tolerance results from changes in both design and materials.

IMPORTANT WEIGHT SAVING

The new advanced design pumps represent a 100% increase in power-to-weight ratio over any other variable displacement pumps now available. The magnitude of this improvement is evident from the fact that every added pound of component increases a missile's gross weight from 30 to 75 pounds.

IMPROVED RELIABILITY

Exceptional capabilities (high speed, long life and contamination tolerance) under extreme conditions . . . even greater under normal application.

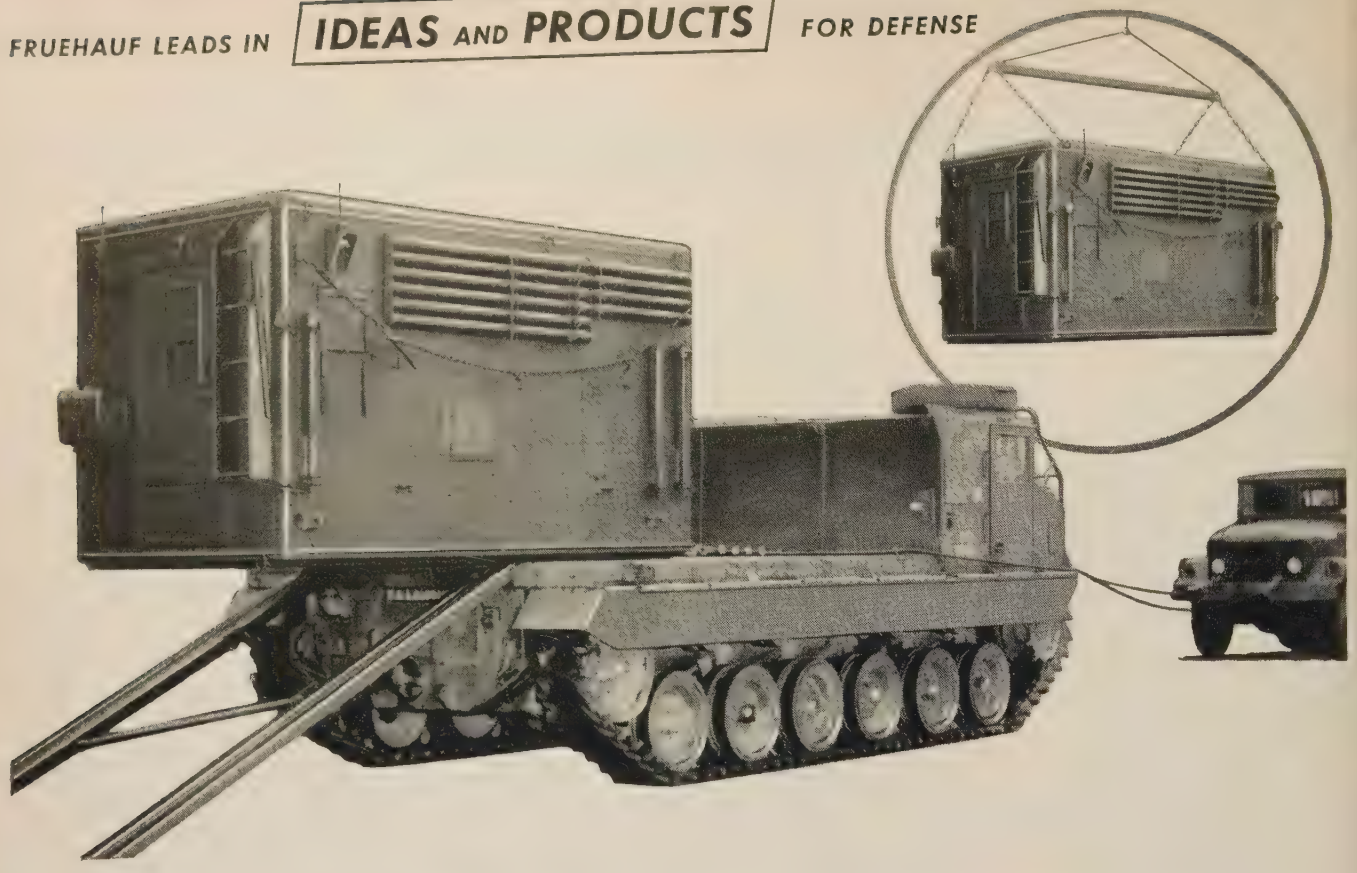
PARTS STANDARDIZATION

Major parts are interchangeable for fixed and variable displacement pumps and for fixed and variable motors in each series. This standardization results in customer savings.

8118

Write in No. 111 on Reader Service Card at start of Product Preview Section

FRUEHAUF LEADS IN **IDEAS AND PRODUCTS** FOR DEFENSE



America's Most Experienced Source Of Military Ground Handling Equipment!

SHELTERS—Since early World War I, Fruehauf has been active in the design and manufacture of mobile shelters for radar equipment, electronic equipment, and generating equipment for military use. Among these shelters have been widely varied units transportable by land, air, and sea.

FOR MISSILES—Fruehauf engineers have been instrumental in the research, development, and design of transporters, containers, and launchers for many of the missiles most vital in the nation's defense program. Fruehauf manufacturing plants have produced thousands of these units.

TRANSPORTERS—The world's leading builder of commercial Trailers, Fruehauf has designed and constructed some 400 specific types of containers and Trailers for military purposes. These include fuel transports, powder haul vans, small cargo units, water tanks, carryalls, weapons transporters, and countless other specialized vehicles.

A SPECIAL SERVICE—Fruehauf's facilities as either a sub or prime contractor include a special staff for quantity production of detail specification drawings, and 10 large, strategically located manufacturing plants with modern, precision machinery for the most demanding jobs.

When confronted with a military ground handling problem, consult Fruehauf—America's most dependable, capable, experienced source of ideas and precision-produced equipment.

MILITARY EQUIPMENT DIVISION

FRUEHAUF TRAILER COMPANY

10942 Harper Avenue, Detroit 32 • 5137 South Boyle Avenue, Los Angeles 58

Write in No. 112 on Reader Service Card at start of Product Preview Section

space/aeronautics

CONFIDENTIAL

July 1959
(good until 9/15/59)

Employment Inquiry Form

(NOT an application for employment)

THIS INQUIRY FORM is a service that makes it easier for the interested reader to explore employment opportunities with organizations featuring recruitments advertising **in this issue.**

To use this Form, follow these simple steps:

(1) Tear out this page.

(2) Check off the organization(s) listed below whose employment offers are of interest to you. **Use typewriter or pencil.**

(3) Turn to the back page of this Form and answer the questions on it.

(4) Mail this form (in a stamped envelope) to:

Reader-Service Dept.
SPACE/AERONAUTICS
205 East 42nd St.
New York 17, N.Y.

We will do the rest and promptly forward a copy of your Inquiry Form to each of the organizations you have checked. Depending on their specific personnel requirements, they will get in touch with you at your home.

I am interested in the employment opportunities at:

- ☐ Aeronutronic System, Inc; A Subsid. of Ford Motor Co. 164
- ☐ Autonetics Div.; North American Aviation 159
- ☐ Bendix Aviation Corp.
  - Bendix-Pacific Div. 166
  - Utica Div. 162
  - York Div. 160
- ☐ Columbus Div.; North American Aviation 76, 162
- ☐ CONVAIR, Astronautics Engrg. Div. 234
- ☐ General Electric Co.
  - Flight Propulsion Div. 160
  - Light Military Electronics Dept. 165
- ☐ Lockheed Aircraft Corp. California Div. 187
- ☐ Los Angeles Div.; North American Aviation 165, 202
- ☐ Martin Co., The; Denver Div. 70
- ☐ North American Aviation
  - Autonetics Div. 159
  - Columbus Div. 76, 162
  - Los Angeles Div. 165, 202
- ☐ Pan American Airways, Inc.; Guided Missile Range Div. 4
- ☐ RCA, Gov't Service Personnel 214
- ☐ Republic Aviation Corp. 163
- ☐ Systems Development Corp. 161
- ☐ Westinghouse Electric Corp. 239

OTHER (Some organizations' recruitment advertising in this issue may have arrived too late for inclusion in the above list. If you are interested in the employment offers of any of these organizations, just note its name and the page number of its advertisement in this space. Please refer only to ads keyed to this form.): _____

_____

_____

NOTE: If you have an immediate interest in any special employment opportunity advertised in this issue and would like to give more details about your qualifications than can be noted on this Form, we advise you to send your resume directly to the person or department given in the advertisement. We'd appreciate it if you'd mention SPACE/AERONAUTICS in your application.

space/aeronautics

CONFIDENTIAL

July 1959

Employment Inquiry Form

Please type or print (with pencil)

(NOT an application for employment)

FIELDS OF INTEREST (in order of importance, note the general fields in which you would like to work—e.g., basic research, dynamics, structures, rocket propulsion, electronic systems, pneumatics, testing, materials, production, ground support, etc.) : _____

SPECIALIZED JOB EXPERIENCE (describe the specific technical areas in which you have worked —e.g., flutter, fatigue, fuel systems, circuit miniaturization, servo systems, hydraulic pumps, tool engineering, orbit mechanics, telemetry, data processing, wind tunnel testing, etc.) : _____

JOBS AND EDUCATION

List your last 3 employers:

EMPLOYER	CITY & STATE	YEARS EMPLOYED	JOB TITLE OR FUNCTION

List your college and university degrees:

SCHOOL	YEARS ATTENDED	DEGREE

Special Training _____

PERSONAL DATA

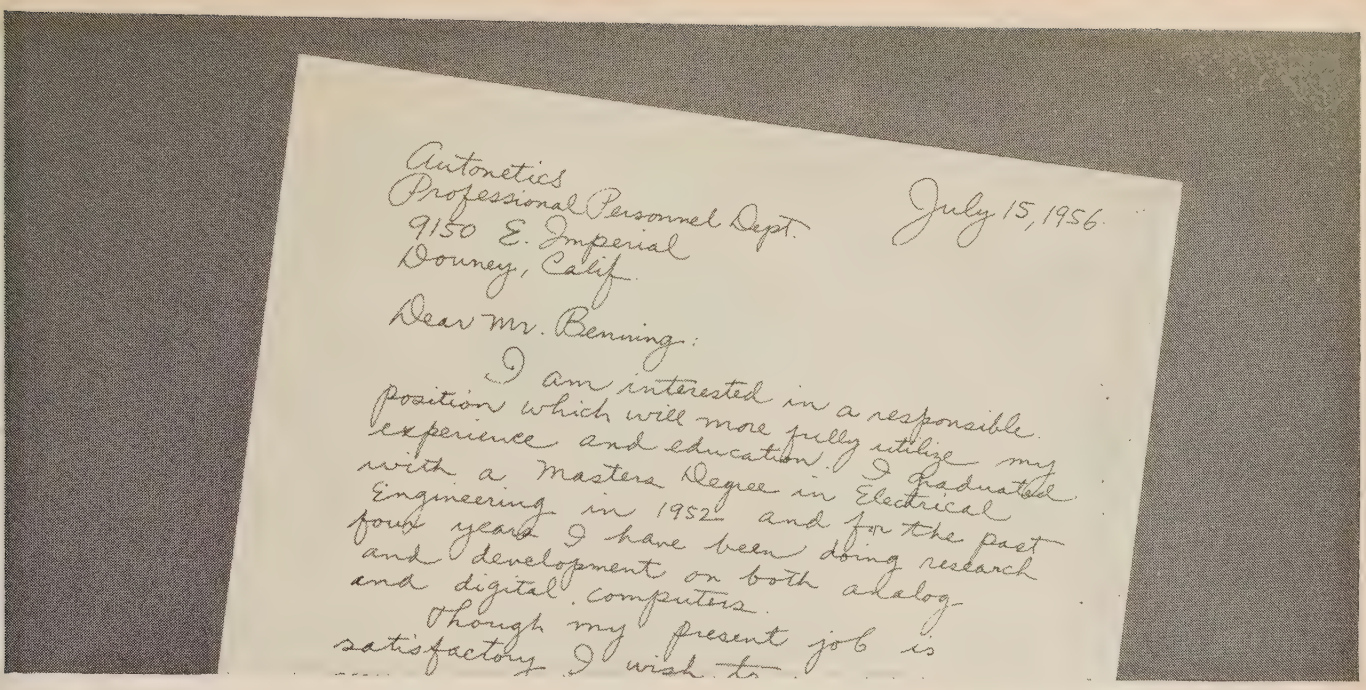
AGE ..... U. S. CITIZEN ☐ YES ☐ NO If not, when do you expect to become a citizen? .....

Name: .....

Home Address: .....

Home Telephone: .....

Make sure you have checked the companies you are interested in on the other side of this Form. Then put the Form in a stamped envelope and mail it to **Space/Aeronautics.**


Autonetics
Professional Personnel Dept.
9150 E. Imperial
Downey, Calif.
July 15, 1956
Dear Mr. Benning:
I am interested in a responsible
position which will more fully utilize my
experience and education. I graduated
with a Masters Degree in Electrical
Engineering in 1952 and for the past
four years I have been doing research
and development on both analog
and digital computers.
Though my present job is
satisfactory I wish to

This letter moved an engineer ahead 5 years

Two years ago a man took 10 minutes to write this letter. Today he enjoys the responsibility and professional standing in the Autonetics Division of North American that might have taken 5 years to achieve elsewhere.

THE 20TH CENTURY'S MOST INTERESTING OPPORTUNITIES FOR THE CREATIVE ENGINEER

Now under way at Autonetics are over 100 projects—military and non-military—involving some of the most arresting and advanced work to challenge the engineering mind today.

WHERE IS YOUR FIELD OF INTEREST?

Inertial Navigation Systems—for aircraft and naval vessels with the organization that successfully flew all-inertial autonavigators more than eight years ago—and whose many-generation family of ever-improved inertial systems for manned and unmanned vehicles have made over 800 successful flights.

Radars—like the lightweight, monopulse type that guides aircraft to targets through fog and darkness and provides all radar functions for both high and low level missions—air-search, automatic tracking, ground-mapping and terrain-avoidance.

Flight Controls—fully automatic and reliable autopilots and landing systems.

Information Processing Equipment—including airborne magnetic tape recorders, transistorized analog or digital computers for both the military and industry, and pace-setting numercial control systems for three-axis position and path control of machine tools for industry.

At finger-tip nearness Autonetics has unique experience, advanced tools and techniques plus precision machine shops turning out work to millionths of an inch tolerances in both developmental and volume quantities.

Opportunities have never been better—at every level of creative engineering from Preliminary research and design to Performance test—**because Autonetics is one of the few companies in the world** designing and quantity-producing systems within the complete spectrum of electronics, electro-mechanics, control engineering and data processing.

Write today and tell us what kind of creative engineering interests you (please include highlights of your education and experience).

Write **D. G.** Benning, Manager, Employment Services.
9150 E. Imperial Highway, Downey, California

Autonetics
A DIVISION OF NORTH AMERICAN AVIATION, INC.

N E R V E C E N T E R O F T H E N E W I N D U S T R I A L E R A

Check Employment Inquiry Form on Page 157

THE MOST IMPORTANT NEWS FOR MECHANICAL DESIGN ENGINEERS TODAY:

308* CAREER POSITIONS OPEN AT GENERAL ELECTRIC'S NEW FLIGHT PROPULSION DIVISION

**(44 to be filled each month for 7 months)*

It's not just the high number of new jobs open at FPD—but the diversity of the opportunities *within one organization* that's important to your future.

You'll find assignments here in Research, Development, Final Design, Production and Test of almost any type of advanced flight propulsion system.

The project range is as broad as the industry, as the list at the right demonstrates. ▶

Equally important to you is the strong sense of obligation we feel at FPD to give each engineer who joins us the maximum opportunity to develop himself professionally. One of the ways we apply this philosophy is to match—and re-match assignments with a man's abilities and interests, as his career progresses.

Most current positions require background in turbomachinery D&D; some do not.

(There are also opportunities at Managerial and Specialist levels for Aerodynamicists, EEs, ChEs, Metallurgists, Physicists and Mathematicians.)

For more information about Flight Propulsion Division—and the professional and living advantages of the new Cincinnati, with its fine, uncrowded schools, some 30 active engineering societies, famous symphony orchestra . . . write for illustrated brochures #50 and #51. *For immediate placement consideration enclose your resume.*

A Partial List of

DIVISION-WIDE PROJECTS AT FPD

. . . CJ 805 aft fan engine to power Convair 600 — **Commercial Engine Dept.**

. . . J79, famous powerplant of many applications, including F-104A — **Production Engine Dept.**

. . . J93 development engine with Mach 3 capability, will power B-70 & F-108 — **Jet Engine Dept.**

. . . A well-advanced VTOL project for vertical and horizontal flight of a fixed wing aircraft . . . exotic propulsion systems using plasma and ion power sources — **Flight Propulsion Laboratory Dept.**

ALSO: High Mach, high energy powerplant in early development . . . a turboshaft project . . . **and other classified programs of unusual interest, with both commercial and military applications.**

Immediate Openings in these Areas

Basic Powerplant Design—Turbomachinery aero • nozzle design • reliability • performance & cycle analysis • installations/applications • component design.

Accessory & Control Systems — Electrical component design • mechanical component design • servomechanisms • reliability.

Test, Evaluation & Manufacturing—Test facilities engineering • aerodynamic instrumentation • manufacturing engineering • controls test equipment design.

Address Dr. Mark Peters, Bldg. 100, Dept.
FLIGHT PROPULSION DIVISION

GENERAL ELECTRIC

Cincinnati 15, Ohio

Check Employment Inquiry Form on Page 157

ENGINEERS:

The kind of work you want in MISSILE ELECTRONICS

The kind of life you want for your family

GET *BOTH* AT

BENDIX YORK

ELECTRONIC ENGINEERS

PHYSICISTS

MECHANICAL ENGINEERS

• Challenging opportunities in CIRCUIT DESIGN, PULSE & VIDEO CIRCUITRY, MICROWAVE, DIGITAL & ANALOG COMPUTERS, SEMI-CONDUCTORS, COMPONENT AND CIRCUIT RELIABILITY.

Interesting work on FUZING TECHNIQUES, BEACONS, SIMULATORS, SPECIAL TEST EQUIPMENT.

• Bendix York offers you the opportunity for rapid professional growth and advancement. Enjoy the small-company atmosphere of an expanding division of one of America's largest engineering and manufacturing corporations . . . And the way of life in and around York, Pennsylvania is ideal for the entire family. It combines the charm and grace of rural living with the many advantages of a dynamic and progressive community.

Let us hear from you!
Address replies to Dept. S
PROFESSIONAL EMPLOYMENT

Bendix
AVIATION CORPORATION
York Division
York, Pennsylvania

"The way of work for you, the way of life for your family!"

Check Employment Inquiry Form on Page 157

Check Employment Inquiry Form on Page 157 ➡

SYSTEM DEVELOPMENT CORPORATION

currently seeking scientists and engineers in various skill areas. s part of this effort, I have been given the opportunity to tell you mething about our organization.

Let me begin by giving you some general facts about the Corporation: DC is a non-profit organization chartered to work in fields rtaining to public welfare, the advancement of science, and tional defense. The Corporation's name implies its function—the velopment of systems. Specifically, we are concerned with large, mplex information processing systems with a high degree of tomation. Development of these systems is accomplished through e application of knowledge in the areas of applied mathematics, gineering, and psychology, to problems of over-all system design, ta processing techniques and optimum man-machine relationships.

Our work is system-oriented, rather than concerned with the sign or manufacture of hardware components. As a result of this pe of specialization, we have assumed major responsibilities in the velopment of systems such as the SAGE (Semi-Automatic round Environment) Air Defense System and the world-wide rategic Air Command Control System, and in the integration of e functional responsibilities of these systems with other military ectronic support systems.

Because the scope of our activities is rapidly increasing, we are panding our staff. In this message I am specifically addressing ung engineers with advanced training and proved analytical ility in the areas of weapons system analysis, noise and formation theory, ECM, electromagnetic intelligence and allied lds. If you are qualified, and our corporate activities sound teresting to you, we would like to hear from you. Address inquiries garding our Santa Monica, California facility to Mr. R. W. Frost, 24 Colorado Avenue, Santa Monica, California. Inquiries regarding ur Lodi, New Jersey facility should be addressed to Mr. R. L. Obrey, ox 2651, Grand Central Station, New York 17, N.Y. These gentlemen ill see that your letter receives prompt attention and confidential eatment."

David Green

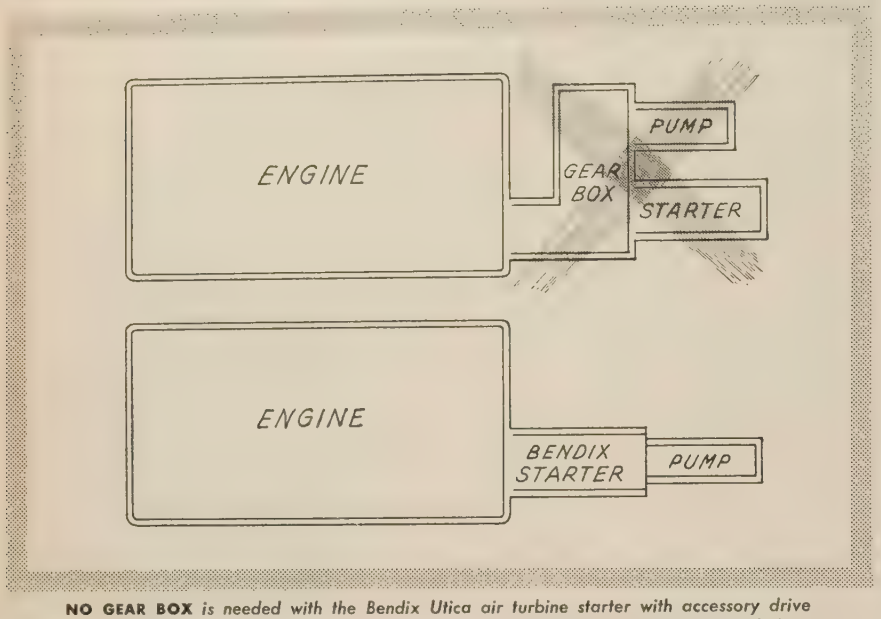
David Green, Assistant Director for Plans,
Operations and Management Research Directorate

SDC

SYSTEM DEVELOPMENT CORPORATION

SANTA MONICA, CALIFORNIA · LODI, NEW JERSEY

BENDIX EXCLUSIVE FOR JET STARTERS: AN EXTRA ENGINE PAD!



NO GEAR BOX *is needed with the Bendix Utica air turbine starter with accessory drive pad. Compare standard engine arrangement, above, with Bendix Utica mounting, below.*

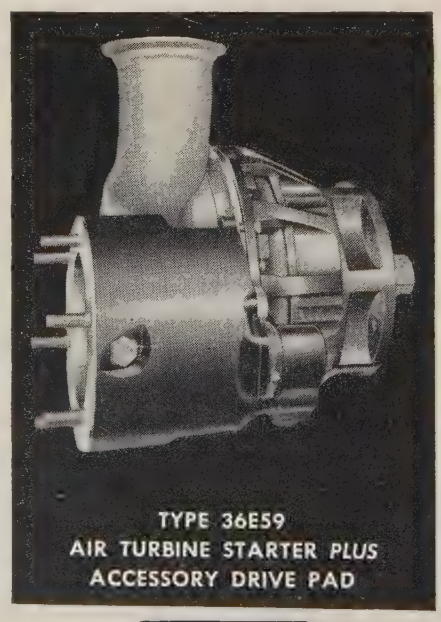
For the first time, Bendix Utica offers an air turbine starter and accessory drive unit, featuring an integral mounting pad for continuous drive of a pump, generator, compressor or similar accessory. Developed by Bendix engineers, the new unit minimizes accessory mounting problems, eliminates the need for a gear box and provides efficient operation with reduced weight and better economy. You get continuous accessory drive during engine operation—and the design can be readily modified to cover a wide range of engine requirements.

Engine starting with this unit is automatic and cockpit-actuated. The engine is carried through light-off by the starter to the established cut-out speed. Then air flow to the turbine is automatically cut off and the unit's starter section coasts to rest, while the engine continues to drive the mounted accessory through the drive shaft and accessory pad gearing.

The starter is adaptable to high-temperature cross-bleed starting for multi-engine installations. It conforms to military specifications and has a minimum service life of 600 starts and 500 operational hours between overhauls. Safe operation is assured by self-limiting runaway speed and reverse overload release mechanism. It's easy to install and mount and provides reliable operation at extreme ambient temperatures.

ADDRESS ALL INQUIRIES TO:
Bendix Utica, 211 Seward Ave., Utica, N. Y.

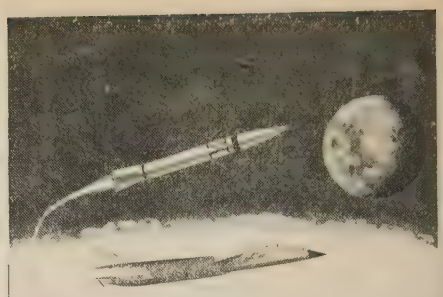
West Coast: 117 E. Providencia, Burbank, Calif.
Canada: Aviation Electric Ltd., 200 Laurentien Blvd., Montreal, Que.
Export Sales and Service
Bendix International, 205 E. 42nd St., New York 17, N. Y.



Bendix Utica Division
UTICA, NEW YORK

Bendix AVIATION CORPORATION

Check Employment Inquiry Form on Page 157



Engineers and Scientists

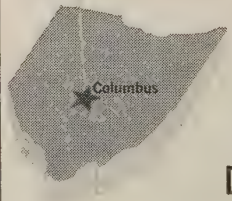
The Columbus Division of North American Aviation, Inc. is increasing the pace of its engineering program. This expansion has created positions for engineers and scientists throughout the Engineering Department of this completely integrated division.

Research and Development, Production Design, Preliminary Design, and Military Operations Analysis are all fields in which weapon systems development is being accelerated.

Specialized groups in such diversified fields as aerodynamics, propulsion, electronics, structures, and human factors, are at work on production aircraft contracts and future space programs.

If you would like to progress in your engineering specialty and still live in the heart of the nation, you may find your answer at NAA-Columbus.

Write to:
H. Keever
Engineering Personnel Manager, Box SA-338
North American Aviation, Inc.
Columbus, Ohio



THE COLUMBUS DIVISION OF

NORTH AMERICAN AVIATION, INC.

Home of the T2J Jet Trainer and the A3J Vigilante

A "TIME-TABLE" FOR SPACE CONQUEST

BY **1963** – INSTRUMENTED PLANETARY SOFT LANDING

BY **1968** – SPACE STATION FOR STAGING TO MOON AND PLANETS

BY **1970-75** – MOON BASE

These predictions were made by Alexander Kartveli, Vice-President for Research & Development at Republic Aviation, and one of the most optimistic of the 56 leading space experts of the world who were consulted by the U.S. House of Representatives Committee on Astronautics & Space Exploration for its report: "The Next 10 Years in Space, 1959-1969."

JOIN REPUBLIC IN AN **INTEGRATED ATTACK** ON PROBLEM AREAS OF **SPACE EXPLORATION**

It's the fervent conviction of engineers and scientists at Republic Aviation that the courageous "Space Time-Table" above is entirely feasible – given a tradition-free, integrated approach to the problems. Such an approach is evident at Republic Aviation. Here, groups of specialists from many disciplines are working in close collaboration to solve problems across the entire spectrum of space technologies, which limit today's interplanetary and upper atmosphere flight capabilities.

Expanded by $35,000,000 last year, Republic's integrated Research and Development program has already produced signal advances in space guidance concepts; in new propulsion systems (plasma, nuclear); in radiation physics; in new materials and processing techniques; in unique hypersonic configurations; and in prototype development of hardware (as an example: hydraulic systems that operate reliably up to 1000°F).

Professional men—who can meet new challenges with enthusiasm and dedication – are urged to look into openings with our R&D groups, working in an atmosphere of exhilarating intellectual adventure.

Electronics
Inertial Guidance & Navigation
Digital Computer Development
Systems Engineering
Information Theory
Telemetry-SSB Technique
Doppler Radar • Countermeasures
Radome & Antenna Design
Microwave Circuitry & Components
Receiver & Transmitter Design
Airborne Navigational Systems
Jamming & Anti-Jamming
Miniaturization — Transistorization
Ranging Systems
Propagation Studies
Ground Support Equipment

Thermo, Aerodynamics
Theoretical Gasdynamics
Hyper-Velocity Studies
Astronautics Precision Trajectories
Airplane/Missile Performance
Air Load and Aeroelasticity
Stability and Controls
Flutter & Vibration
Vehicle Dynamics & System Designs
High Altitude Atmosphere Physics
Re-entry Heat Transfer
Hydromagnetics
Ground Support Equipment

Plasma Propulsion
Plasma Physics
Gaseous Electronics
Hypersonics and Shock Phenomena
Hydromagnetics
Physical Chemistry
Combustion and Detonation
Instrumentation
High Power Pulse Electronics

Nuclear Propulsion and Radiation Phenomena
Nuclear Weapons Effects
Radiation Environment in Space
Nuclear Power & Propulsion Applications
Nuclear Radiation Laboratories

Send resume in complete confidence to: Mr. George R. Hickman, Engineering Employment Manager, Dept. 6G

REPUBLIC AVIATION

Farmingdale, Long Island, New York

Check Employment Inquiry Form on Page 157

ENGINEERS

experienced in missile and gas turbine fields

SEND FOR THIS BROCHURE

GET THE FACTS about Solar and your *triple opportunity* — and do it without delay.

***Opportunity* #1:** The chance to get in on the ground floor and gain a key creative position with tremendous potential. Solar is humming with exciting and challenging programs. Solar's Missile and Space Group has several highly advanced projects under way, including a new ARPA Project involving a completely new anti-missile defense system. Many openings also exist in Solar's fast-moving gas turbine programs.

***Opportunity* #2:** You don't get lost in the crowd! Solar is a medium-sized company (2500 people in San Diego) with a successful history since 1927. Personnel policies are advanced. Salary and performance reviewed semi-annually. Liberal relocation allowances. Professional status of engineers is fully appreciated and recognized. A new 60,000 sq. ft. engineering building, necessitated by expanding research and development, will be completed in 1959 on the edge of San Diego Bay.

***Opportunity* #3:** The chance to live better in sunny San Diego. This famous resort area has the finest year-around climate in the U.S. Recreational, cultural and educational facilities are excellent. You and your family will enjoy life more at Solar in San Diego.

Send for brochure giving complete details. Write to Louis Klein, Dept. E-413, Solar Aircraft Company, 2200 Pacific Highway, San Diego 12, Calif. Why not send along your resume of qualifications to save time?

SOLAR
AIRCRAFT COMPANY
SAN DIEGO
DES MOINES

Check Employment Inquiry Form on Page 157

ENGINEERS & SCIENTISTS

Research Opportunities

Aeronutronic Systems, Inc., a dynamic new name in science and research, has immediate need for qualified people to staff senior positions at its new *Research Center* in *Newport Beach*, Southern California. The Space Technology Division of this rapidly expanding Ford Motor Company subsidiary has career openings in the following fields of interest:

VEHICLE TECHNOLOGY

- Aerodynamic design and testing
- Rocket engine development
- Rocket nozzle and re-entry materials
- High temperature chemical kinetics
- Combustion and detonation theory
- Combustion thermodynamics
- High temperature structural plastics & ceramics
- Advanced structures
- Rocket vehicle systems

MISSILE DEFENSE

- Supersonic aerodynamics
- Aerothermodynamics
- High temperature heat transfer
- Space physics
- Re-entry programs

ASTRO SCIENCES

- Space electronics
- Guidance & control
- Communications
- Instrumentation
- Experimental physics
- Plasma and magnetohydrodynamics studies

Visit Aeronutronic's exhibit booth 3822-24 at the WESCON show. Qualified applicants are invited to send resumes and inquiries to Mr. R. W. Speich, Aeronutronic Systems, Inc.

AERONUTRONIC
a subsidiary of
FORD MOTOR COMPANY
Bldg. 11 Box 451
Newport Beach, California
ORiole 3-2520
Newport Beach • Santa Ana • Maywood, California

Check Employment Inquiry Form on Page 157

DYNAMICS ENGINEERS

Immediate openings for vibration, flutter, and dynamic analysis engineers to work on the most advanced weapon systems —such as the B-70, the F-108, and the X-15, first manned space ship.

A background in AE, ME, or other applicable experience is necessary. Qualified vibration engineers will calculate and measure vibration levels for consulting on procedures to insure crew comfort and work out vibration environment problems on equipment of particular airframes. The flutter and dynamic analysis engineers will evaluate flutter characteristics, including servo systems, of particular airframes by analytical techniques and by the use of dynamic models, and conduct other studies relating to gust penetration, landing, and taxi conditions.

For more information please write to: Mr. P.G. Stevenson, Engineering Personnel, North American Aviation, Inc., Los Angeles 45, California.

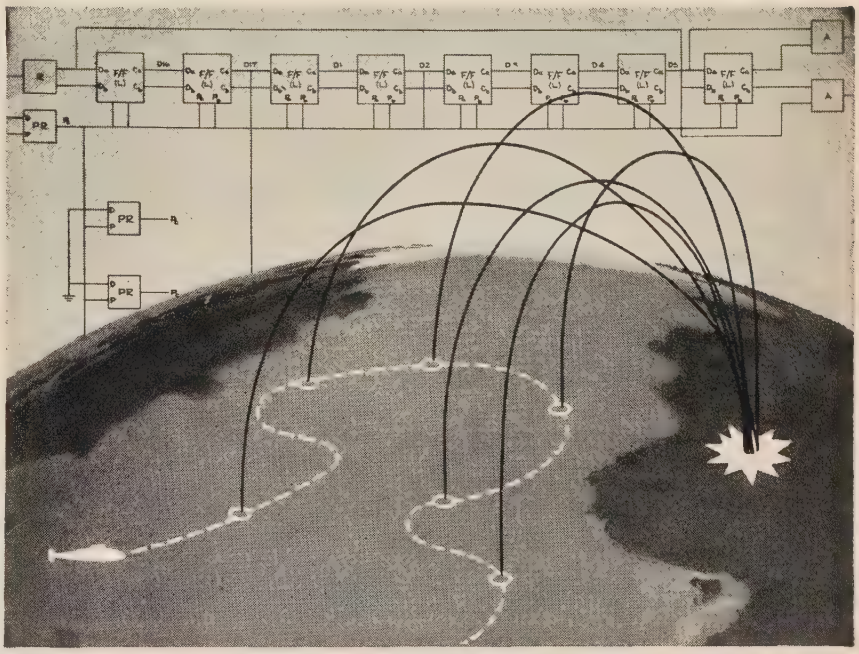
THE LOS ANGELES DIVISION OF

NORTH AMERICAN AVIATION, INC.

Opportunities to work on

FIRE CONTROL AND GUIDANCE COMPUTER ELECTRONICS

for the **POLARIS MISSILE**



High Priority Project Presents Unique Challenges to Computer Engineers

Design and development men at the Light Military Electronics Department of General Electric are now working on one of the most stimulating problems ever faced by computer engineers.

It is one of the functions of the fire control computer electronics to keep the Polaris missile—now under development—always battle-ready, with a freshly calculated trajectory toward its pre-programmed target. The computer electronics *operate continuously,* constantly plotting the submarine's changing position, taking into account all parameters of speed, direction, angular disturbance, compass references, etc., and cranking new trajectory equations into the memory circuits of Polaris' guidance computer electronics.

The Guidance Computer furnishes the commands which guide the missile to its pre-programmed target on the basis of inputs from the fire control computer, and its own inertial reference sensor.

Current assignments on Polaris Computer Design & Development are representative of the professionally advanced work always in progress at Light Military. Engineers chosen for these positions will find their own advancement can be rapid. Promotion is fully based on individual contributions, backed by performance appraisals.

For prompt consideration, write in confidence to Mr. W. Gilmore, Dept. 60-MG

LMED

LIGHT MILITARY ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

FRENCH ROAD, UTICA, NEW YORK

Check Employment Inquiry Form on Page 157

TELEMETERING ENGINEERS NEEDED

IN SOUTHERN CALIFORNIA

Bendix-Pacific

the major source for telemetering systems and components, offers you a unique opportunity to fully use your ability with a rewarding future as a qualified engineer.

Have you had two or more years experience in the design of VHF or UHF transmitters?

. . . in airborne packaging?

. . . in transistor circuitry?

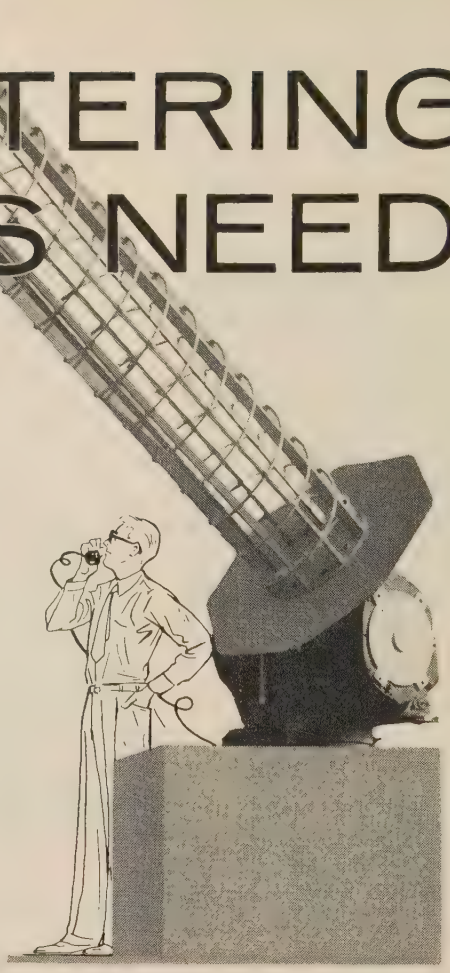
If you have, we want to talk to you.

Please send resume to **W. C. WALKER**
ENGINEERING EMPLOYMENT MANAGER

Bendix-Pacific
DIVISION OF BENDIX AVIATION CORPORATION

11630 Sherman Way, NORTH HOLLYWOOD, CALIFORNIA

Other High-Level Electronic Engineering Positions Available



Check Employment Inquiry Form on Page 157

Investigating Employment Opportunities?

Want more information about employment opportunities offered by companies advertising in this issue? Then be sure to give complete data about your job interests, experience and education when filling in the "Employment Inquiry" form.

Although not an application for employment, it provides employment managers with information to evaluate your capabilities—and in turn gives your request immediate consideration.

Check the "Employment Inquiry" form for details.

For more detailed information... on Products or Service use this "TIME-SAVER" Card

1. *Write* reader service number for each editorial item or advertisement of interest in box on card. (Reader service numbers appear next to all editorial items and advertisements.)

2. Fill out your Name, Title, Company, Address and check industry activity.

3. Tear out and mail . . . no postage necessary. SPACE/AERONAUTICS' Reader Service Department will contact the manufacture for you.

NAME..... TITLE.....

COMPANY.....

ADDRESS.....

CITY..... STATE.....

PRINT READER SERVICE NUMBERS HERE

SPACE/AERONAUTICS
Reader Service Card
JULY 1959
(Not good after 9-15-59)

Does your work apply to:
(Check appropriate box or boxes)
AIRCRAFT PROJECTS ☐
MISSILE PROJECTS ☐
SPACECRAFT PROJECTS ☐

NAME..... TITLE.....

COMPANY.....

ADDRESS.....

CITY..... STATE.....

PRINT READER SERVICE NUMBERS HERE

SPACE/AERONAUTICS
Reader Service Card
JULY 1959
(Not good after 9-15-59)

Does your work apply to:
(Check appropriate box or boxes)
AIRCRAFT PROJECTS ☐
MISSILE PROJECTS ☐
SPACECRAFT PROJECTS ☐

NAME..... TITLE.....

COMPANY.....

ADDRESS.....

CITY..... STATE.....

PRINT READER SERVICE NUMBERS HERE

SPACE/AERONAUTICS
Reader Service Card
JULY 1959
(Not good after 9-15-59)

Does your work apply to:
(Check appropriate box or boxes)
AIRCRAFT PROJECTS ☐
MISSILE PROJECTS ☐
SPACECRAFT PROJECTS ☐

FIRST CLASS
Permit No. 16734
New York, N. Y.

BUSINESS REPLY MAIL
No Postage Stamp Necessary If Mailed in the United States

POSTAGE WILL BE PAID BY

SPACE/AERONAUTICS

205 EAST 42nd STREET

NEW YORK 17, N. Y.

Reader-Service Dept.

FIRST CLASS
Permit No. 16734
New York, N. Y.

BUSINESS REPLY MAIL
No Postage Stamp Necessary If Mailed in the United States

POSTAGE WILL BE PAID BY

SPACE/AERONAUTICS

205 EAST 42nd STREET

NEW YORK 17, N. Y.

Reader-Service Dept.

FIRST CLASS
Permit No. 16734
New York, N. Y.

BUSINESS REPLY MAIL
No Postage Stamp Necessary If Mailed in the United States

POSTAGE WILL BE PAID BY

SPACE/AERONAUTICS

205 EAST 42nd STREET

NEW YORK 17, N. Y.

Reader-Service Dept.

For more detailed information... on Products or Service use this "TIME-SAVER" Card

1. *Write* reader service number for each editorial item or advertisement of interest in box on card. (Reader service numbers appear next to all editorial items and advertisements.)

2. Fill out your Name, Title, Company, Address and check industry activity.

3. Tear out and mail . . . no postage necessary. SPACE/AERONAUTICS' Reader Service Department will contact the manufacture for you.

product index to advertising

THIS IS A SPECIAL REFERENCE to the product information given in the advertisements in this issue. It is intended solely to help the reader make the best use of these ads. Therefore the index does not necessarily cover all the products made by each advertiser. Also, cross-listings are not intended to exhaustively describe each product but merely to make sure that each product can be found with reasonable ease by the reader looking for it.

Similar indexes to services and employment opportunities featured in ads follow this index.

Advertisements for which complete proofs were not available to the Editorial Department by the closing date are not necessarily covered by these indexes. (Proofs can be forwarded internally by the Production Department only for advertisements meeting the closing dates.)

For more detailed information on any product or service advertised in this issue or featured in its Product and Data Reviews, use the handy Reader-Service Card.

A

AC Systems ... 174
APUs ... 233
ASW Equipment ... 258
Accelerometers ... 134
Actuators
  Electric ... 151
  General ... 102, 103
  Pneumatic ... 5
  Release ... 37
Aircraft
  Fixed Wing ... 33, 137, 142, 266
Alloys
  Titanium ... 101
  Vacuum-Melted ... 101
Amplifiers ... 184
Antennas, Airborne ... 109

B

Base Line Equipment ... 148
Bearings
  Ball ... 107, 196, 236
  Roller ... 25
  Spin ... 260
Blocks
  General ... 89, 128
  Tension ... 63
Bushings, Ball ... 107

C

Chemical Analysis Systems ... 211
Chilling Equipment ... 244
Clamps ... 128
Cloth, Tracing ... 86
Communications System Equipment ... 258
Communications Systems ... 181
Compasses, Drafting ... 171
Compensators, Cam ... 109
Connectors,
  Electric ... 12, 20, 64, 98
Control System Equipment
  Antenna ... 103
  Flight ... 102
  Pneumatic ... 177
Control Systems
  Hydraulic ... 15
  Industrial ... 211
Converters, Analog-Digital ... 109
Cooling Systems ... 144
Counters, Azimuth ... 109
Couplers, Directional ... 188
Couplings ... 177, 256, 264
Cryogenic Systems ... 211

D

Data Processing Systems ... 211
Data Processing System Equipment ... 258
Data Recording System Equipment ... 258
Data Recording System Equipment ... 169, 183, 183, 211
De-Icers ... 9

E

Escape System Equipment ... 37
Exchangers, Heat ... 177
Extrusions ... 197

F

Fabrications, Metal ... 86
Fasteners
  Cold-Rolled ... 72
  General ... 6, 63, 89, 190
  Quarter-Turn ... 247
Filing System ... 148
Filters ... 259
Follow-Up Mechanisms ... 109
Fuel System Equipment ... 204
Fuel Systems ... 151
Fuzing Equipment ... 258

G

Gages
  Bore ... 242
  Pressure ... 192
Gasket Materials ... 96
Gear Assemblies ... 109
Generators
  Motor ... 109, 217
  Rate ... 109, 217
  Starter ... 96
  Tach ... 109, 189, 217
Ground Handling Equipment 95, 156
Ground Support Equipment 7, 27, 81, 96, 97, 148, 177, 181
Ground Support Systems ... 211
Ground Transport Equipment ... 95
Gyros ... 109

H

Hose ... 68, 74
Hydrogen Peroxide ... 78

I

Indicators, Engine Temperature 88
Injectors, Fuel ... 204
Inserts
  Lock ... 6
  Threaded ... 190
Insulation ... 132
Inverters ... 188

L

Latches, Chassis ... 62
Launch Systems ... 81
Lights
  Switch ... 145
  Warning ... 145

M

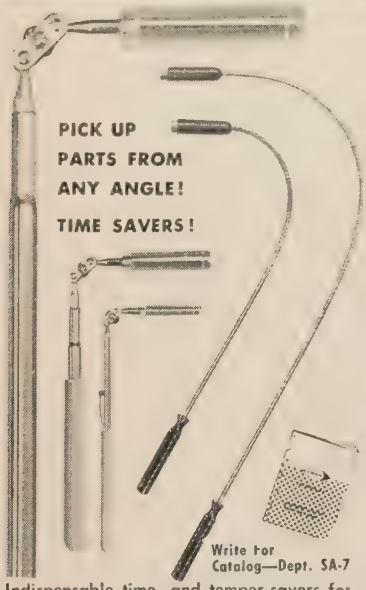
Materials ... 84, 87, 101, 117, 149, 173, 192, 199, 229
Missiles
  Air-to-Ground ... 178
  Ground-to-Ground ... 266
  Underwater-to-Surface ... 201
Monitors ... 77
Motors
  Fractional-HP ... 153
  Gearhead ... 109
  Integral-HP ... 153
  Servo ... 109, 182
  Timing ... 250

N

Navigation System Equipment ... 258
Navigation Systems ... 67
Nozzles, Rocket ... 139

more on next page

NEW STRONGER THAN EVER **Magnetic Retrieving Tools**



Indispensable time- and temper-savers for mechanics and service men. Pick up elusive nuts, bolts, pins and washers from any angle. Precision-made exclusive Ullman ball joints hold firmly in position whatever the angle.

ULLMAN — ULLMAN DEVICES CORP. RIDGEFIELD, CONN.

Write in No. 114 on Reader Service Card

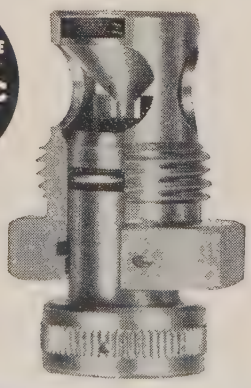
Just a twist of the wrist...

FOR CHIP INSPECTION—

NO WIRES • NO TOOLS • NO DRAIN PANS...

Tedeco Bayonet Type Self-Closing Magnetic Drain Plugs make routine inspection easy. An inward push and slight turn removes plug. Valve closes automatically. For drain or refill, bayonet connection hose available.

TEDECO BAYONET TYPE SELF-CLOSING MAGNETIC DRAIN PLUG



WRITE FOR FURTHER INFORMATION

TECHNICAL DEVELOPMENT CO. Glenolden, Pa. — LUdlow 3-3330

Write in No. 115 on Reader Service Card

Nuts
- Blind 89
- Lock 63

O

Oscillographs 213

P

Paper
- Chart 169
- Reproduction 65

Parts
- Metal 203
- Missile 203
- Teflon 68

Pedestals, Antenna 109
Pencils 73
Pens, Ruling 171
Platforms, Stable 109
Power Conversion Units 205
Power Packs, Hydraulic 97
Production Equipment & Methods 138, 148, 168
Programers 152
Propellants 56
Pumps
- Compressor 13
- Coolant 13
- Fuel 13
- Hydraulic 13, 155
- Vacuum 194

R

Radar, Airborne 258
Readouts, Digital 193
Receivers, Radio 188
Recorders
- Fire Control System 90
- X-Y 183

Relays
- Microminiature 141
- Miniature 216
- Time Delay 256

Resistors 218
- Resolvers 108

Retrieving Tools 168
Rivets 89
Rubber, Silicone 84, 117, 192

S

Screwdrivers 138
Scribers 171
Sensors, Speed 37
Servo Assemblies 109
Shims, Laminated 260
Sleeving 150
Steels
- Alloys 87
- Carbon 87
- General 173, 229
- Stainless 149, 199
- Vacuum-Melted 101

Straps, Harness 128
Supports
- Duct 177
- Line 184

Switches
- General 145
- Hermetic 145
- Overload 176
- Pressure 13
- Push-Button 145
- Rotary 145
- Toggle 145
- Trigger 176
- Synchros 109

T

Tape
- Instrumentation 251
- Pressure-Sensitive 99
- Teflon 240

Teflon Shapes 68
Terminals 92
Test Equipment
- Automatic 79
- General 192

Test Systems 211
Thermometers 192
Thread Compounds, Anti-Seize 218
Tires, Aircraft 3
Training Equipment 90
Transducers
- Magnetic 226
- Pressure 190

Transistors 235, 245
Transmitters 109
Tubing 68, 106, 135, 243

V

Valves
- Ball 7
- Check 230
- General 177
- Plug 191
- Shuttle 190
- Solenoid 94
- Throttle 192

W

Weapon Systems 151
Wire
- Silicone 83
- Thermocouple 90

Wrenches, Torque 148

Service Index to Advertising

Processing, Film 226
Production
- Aluminum Parts 71
- Aluminum Shapes 71
- Assemblies 31, 119
- Boring 78
- Coating 104
- Components 78
- Control Systems, Electro-mechanical 39
- Fixtures 78
- Gages 78
- Grinding 78
- Instruments 22
- Machining 78
- Parts, General 31
- Parts, Refractory-Metal 104
- Structures 2
- Subassemblies 78
- Subsystems 119

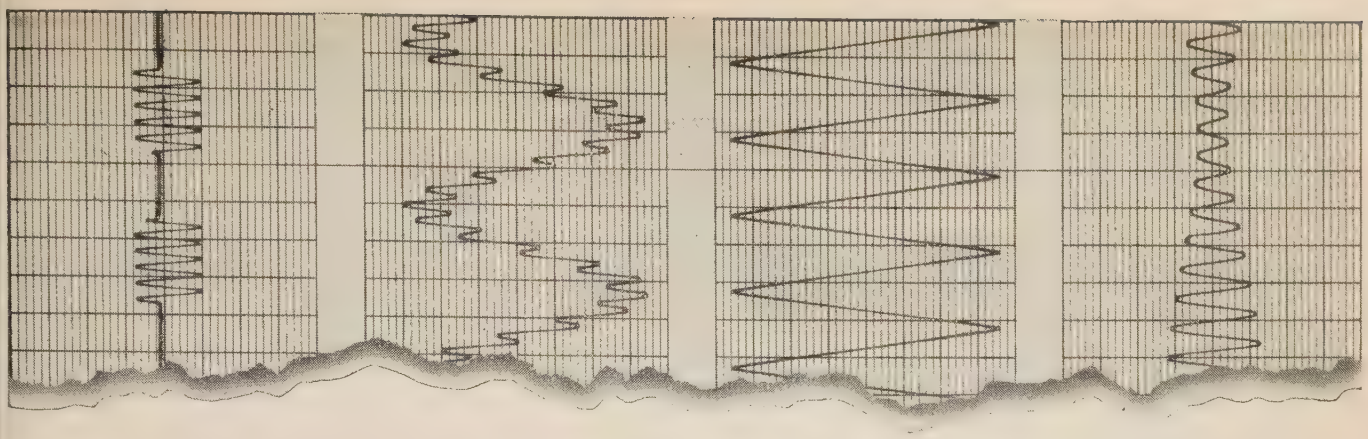
Research & Design
- Assemblies 31, 119
- Control Systems, Electro-mechanical 39
- Parts 31
- Subsystems 119

Employment Opportunities Index to Advertising

70, 76, 79, 111, 159, 160, 161, 162, 164, 165, 187, 202, 234

CLASSIFIED

COLLECTIONS
For the Industry
ALL OVER THE WORLD
Airline and Aeronautical
Accounts Receivable
No Collections—No Commissions
STANDARD ACTUARIAL WARRANTY CO.
220 West 42 St., N. Y. 36, N. Y.
LO 5-5990



TO USERS OF BRUSH DIRECT-WRITING RECORDERS!

Specify only Brush engineered chart paper for highest quality records!

THERE is an important difference in chart papers and recording supplies . . . and the reason is that all Brush equipment and supplies are *engineered as a total entity.*

Chart paper, pens, ink and the equipment are specifically designed to realize the full potential of the recording system. The result —highest quality chart records attainable.

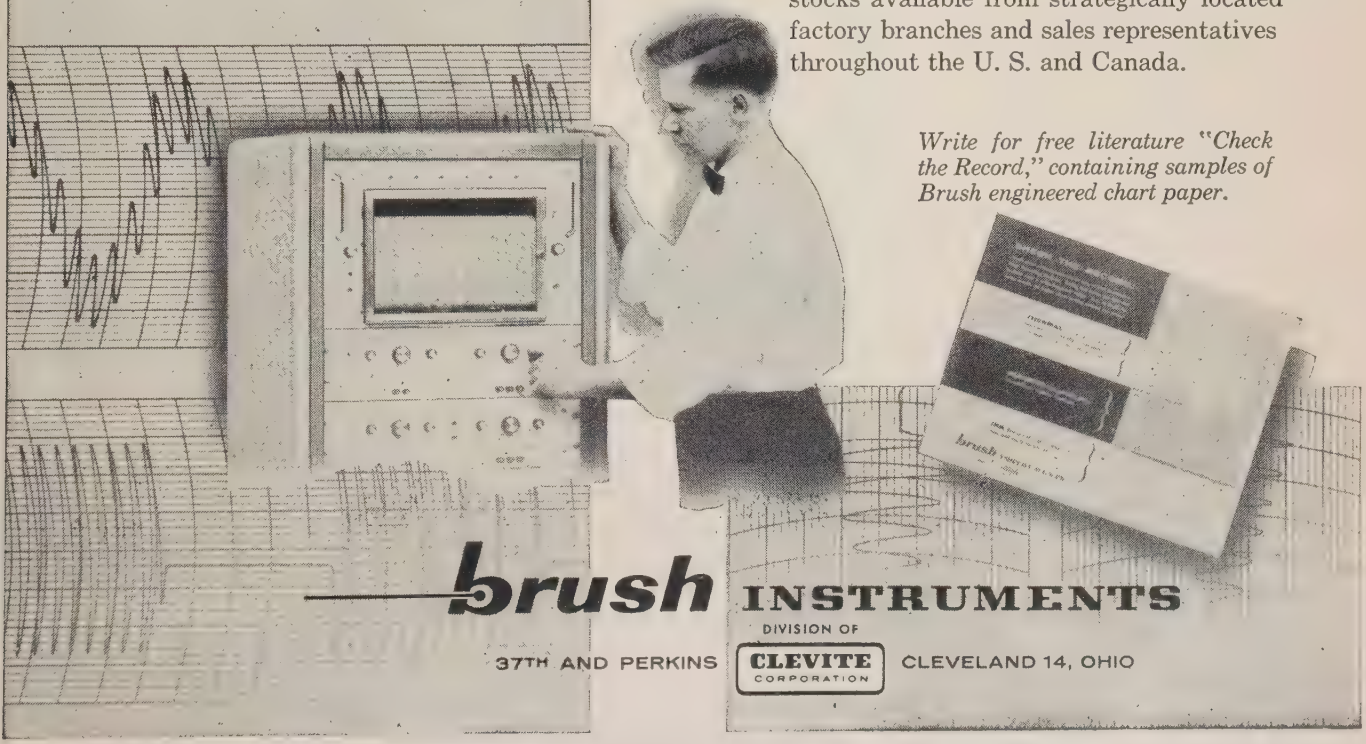
Brush chart paper is:

—precision ruled to insure exact calibration.
—dimensionally stable in any atmosphere.
—super-smooth to minimize erratic trace and pen wear.

Your records are accurate, permanent, immediately usable, legible and easily reproduced when you use Brush chart paper.

For the most dependable results from your Brush equipment — make certain you specify Brush chart paper and supplies. Complete stocks available from strategically located factory branches and sales representatives throughout the U. S. and Canada.

Write for free literature "Check the Record," containing samples of Brush engineered chart paper.



brush INSTRUMENTS

DIVISION OF

37TH AND PERKINS — CLEVITE CORPORATION — CLEVELAND 14, OHIO

Write in No. 116 on Reader Service Card as start of Product Preview Section

advertisers' index

A

Acme-Newport Steel Co. 87
Adel Precision Prods. Div.; Gen. Metals Corp. 28, 184
Aeronca Mfg. Co. 253
Aeronutronic Systems, Inc.; A Subsid. of Ford Motor Co. 164
Aero Supply Mfg. Co., Inc. 94
A. G. A. Div.; Elastic Stop Nut Corp. 256
Airborne Accessories Corp. 102, 103
AiResearch Mfg. Co. 233
Allegheny Ludlum Steel Corp. 199
Allied Research Prods., Inc. 220
Aluminum Co. of America 197
American Chain & Cable Co. 186
AMP, Inc. 92
Amphenol Electronics Corp. 64
Anaconda Aluminum Co. 71
Armco Steel Corp. 149
Armstrong Whitworth Aircraft, Ltd. .. 188
Arnoux Corp. 36
Automotive & Aircraft Div. 186
Autonetics Div.; North American Aviation 66, 67, 90, 148, 159
AVCO Mfg. Corp.; Crosley Div. Second Cover

B

B & H Instrument Co., Inc. 88
B & K Instruments, Inc. 232
Barber Colman Co. 38, 39
Barco Mfg. Co. 198
Barden Corp., The 177
Beattie-Coleman, Inc. 152
Bendix Aviation Corp.
Bendix-Pacific Div. 166
Elipse Pioneer Div. 221
Eclipse Pioneer Components Div. 108, 109
Scintilla Connector Div. 20
Utica Div. 162
York Div. 160
Bishop & Co., J. 106
B. M. B. Sales, Ltd. 236
Bohanan Mfg. Co. 219
Breeze Corp. 96
Bristol Co., The 206
Brush Instruments Div.; Clevite Corp. 169
Buggie, H. H.; Burndy Corp. 12
Bulova Watch Co.; Govt. & Ind. Sales 22
Burndy Corp. 12

C

Camloc Fastener Corp. 62
Chandler-Evans 5
Chandler Products Corp. 72
Chicago Pneumatic Tool Co. 153
Cleveland Tool & Die Co. 78
Clevite Corp. 169
Clifton Precision Prods. 114
Columbia-Geneva Steel Div. 135
Columbus Div.; North American Aviation 33, 76, 162
Colvin Laboratories, Inc. 190
Con-Elco 240
Connecticut Hard Rubber 84, 192, 240
Consolidated Controls Div.; Consol. Diesel Elect. Corp. 211
Consolidated Electrodynamics Corp. .. 16
Consolidated Film Industries 226
CONVAIR, A Div. of Gen. Dynamics Corp. ..... Fourth Cover
CONVAIR, Astronautics Engrg. Div. . 234
Crucible Steel Co. 100, 101
Cubic Corp. 193

D

Daystrom Transicoil Div.; Daystrom, Inc. 119
Delavan Mfg. Co. 204
Delco Radio Div. of G. M. C. 245
Deutsch Co., The 98
Donner Scientific Co. 134
Dow Corning Corp. 117
DuKane Corp. 181
du Pont de Nemours & Co., E. I. 65

E

Eastern Industries, Inc. 144
Elastic Stop Nut Corp. 35
Electric Auto Lite Co. 82, 83
Electro-Flex Heat, Inc. 218
Electro Products Labs. 226
Ex-Cell-O Corp. 31

F

Faber-Castell Pencil Co., Inc., A. W. .. 73
Falstrom Co. 86
Felt Products Mfg. Co. 218
Formsprag Co. 224, 225
Fruehauf Trailer Co. 156

G

Gardner Denver Co. 228
Garrett Corp. 233
General Electric Co.
Apparatus Sales Div. 139, 140, 141
Flight Propulsion Div. 160
Light Military Electronics Dept. .. 60, 165
General Motors Corp.
Delco Radio Div. 245
New Departure Div. 25
G-M Laboratories 182
Goodrich Co., B. F. 9
Goodyear Tire & Rubber Co., Inc. 3
Great Lakes Mfg. Co. 13
Groov-Pin Corp. 190

H

Haydon Co., A. W. 250
Heiland Div.; Minneapolis-Honeywell 212, 213
Heli-Coil Corp. 6
Hetherington, Inc. 145
Hi Shear Rivet Tool Co. 89
Hitemp Wires, Inc. 246
Hydraulic Research & Mfg. Co. 15
Hydromatics, Inc. 7

I

Ingersoll Kalamazoo Div.; Borg Warner Corp. 207
Instrument Development Labs, Inc. 254
International Nickel Co. 238
International Telephone & Telegraph Corp.; Ind. Prods. Div. 231

J

Jack & Heintz, Inc. 174
James Pond Clark 230
Janitrol Aircraft Auto Div. 185
Johns Manville Corp. 132

K

Kaynar Co., The 91
Kearfott Co., Inc. 242
Kelsey-Hayes Corp. 262
Keuffel & Esser Co. 86, 171
Kinney Mfg. Div.; The N. Y. Air Brake Co. 194

L

Laminated Shim Co. 260
Leonard Co., Wallace O. 241
Linde Co.; Div. of Union Carbide Corp. 104
Lockheed Aircraft Corp.
Calif. Div. 187
Missiles & Space Div. 110, 111, 200, 201
Los Angeles Div.; North American Aviation 136, 137, 165, 202
Lukens Steel Co. 229

M

Magnavox Procurement Div. 258
Magnetic Amplifiers 188
Magnetic Controls 184
Marsh Corp., Jas. J. 192
Martin Co., The 80, 81
Martin Co., The; Denver Div. 70
M C Mfg. Co. 190
Metals & Controls Div.; Texas Instruments, Inc. 222
Micro Switch Div.; Minneapolis-Honeywell Regulator Co. 255
Midland Industrial Finishes Co. 236
Midway Aircraft Instrument Corp. 227
Minneapolis-Honeywell Regulator Co.
Heiland Div. 212, 213
Micro Switch 255
Minnesota Mining & Mfg. Co.
Chemical Prods. Div. 146, 147
Industrial Tape Div. 99
Magnetic Prods. Div. 251
Missiles Ind. Div. 215
Missiles Div.; North American Aviation 178

N

N J E Corp. 249
National Tube Div.; U. S. Steel Corp. 135
New Departure Div. of G. M. C. 25
New York Air Brake Co., The 223
North American Aviation
Autonetics Div. 66, 67, 90, 148, 159
Columbus Div. 33, 76, 162
Los Angeles Div. 136, 137, 165, 202
Missiles Div. 178
Rocketdyne Div. 56
Northrop Aircraft, Inc. 27, 142

O

On Mark Couplings, Inc. 256
Oster Mfg. Co., John 189

P

PacAero Engineering Corp. 195
Pacific Scientific Co. 37
Pan American Airways, Inc.; Guided Missiles Range Div. 4
Parker Seal Co. 18
Pratt & Whitney 69
Purolator Products, Inc. 259

R

R C A
Defense Electronics Div. 63
Govt. Service Personnel 214
Raybestos-Manhattan, Inc. 68
Reeves Instrument Corp. 261
Republic Aviation Corp. 163
Resistoflex Corp. 252
Rocketdyne Div.; North American Aviation 56
Roll & File Systems, Inc. 148
Rolle Mfg. Co. 209
Rollway Bearing Co. 203
Ryan Aeronautical 112

S

Sanborn Co. 183
Sciaky Brothers, Inc. 257
Snap-On Tools Corp. 138
Snap-Tite, Inc. 264
Solar Aircraft Co. 151, 164
Southco Div.; South Chester Corp. 247
Southwest Prods. Co. 196
Spencer Div.; Metals & Controls Corp. 222
Standard Pressed Steel Co. 208
St. Louis Car Co. 95
Stromberg-Carlson 79
Sturtevant Co., P. A. 148
Superior Tube Co. 243
Surface Combustion Corp.; Janitrol Aircraft Auto Div. 185
Systems Development Corp. 161

T

Technical Development Co. 168
Telecomputing Corp. 191
Texas Instruments 237
Thermocal, Inc. 176
Thermo Electric Co., Inc. 90
Thiokol Chemical Corp. ..... Third Cover
Thomson Industries, Inc. 107
Titeflex, Inc. 74
Tung-Sol Electric, Inc. 205

U

Ullman Devices Corp. 168
Union Switch & Signal Div.; Westinghouse 216, 217
United Aircraft Corp.; Pratt & Whitney 69
United Aircraft Products 210
U. S. Steel Corp. 135, 172, 173
U. S. Steel Export Co. 135
U. S. Steel Supply Div. 135
Utica Metals Div.; Kelsey-Hayes Corp. 262

V

Varflex Corp. 150
Vickers, Inc.; Div. of Sperry Rand 154, 155
Vickers, Inc.; Marine & Ordnance Dept. 97

W

Washington Steel Corp. 235
Westinghouse Electric Corp. 130, 131, 239
Weston Electrical Instrument Corp.; Div. of Daystrom, Inc. 77
White Industrial Div., S.S. 244
Whitney Metal Tool Co. 230

Some Ideas

for your file of practical information on drafting and reproduction from

KEUFFEL & ESSER CO.

One of the ways to judge a skilled craftsman is by the tools he uses. They're invariably the best he can find – chosen to lighten his work, sharpen his skills. And, if the craftsman is a draftsman, they are, more often than not, products of K&E.

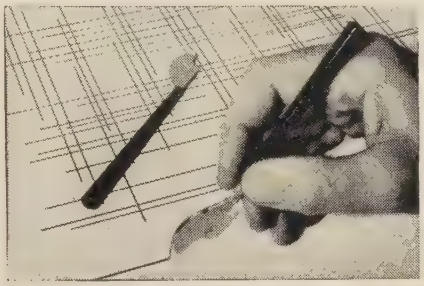
It may be that some of these products have escaped your attention (after all, we offer something over 8000 items). That's why we suggest you pay a visit to your K&E dealer whenever you can. It's a liberal education on what's new – as well as what's tried and true – in drafting equipment.

You'll find many products like these which can be highly useful in your work . . .

K&E "Quick Set" Bow Compass

The most remarkable feature of this compass is the speed and ease with which you can change settings—from diameters of 12 inches to 1/16 inch. With one hand, you can increase or decrease radii instantly and exactly. To go from small to larger radius, just press a spring release, and the legs will expand automatically. Stop approximately where you want, and make precise adjustments with a micrometer screw. To go from large to small, simply squeeze the legs of the compass together, then adjust precisely.

The K&E Quick Set combines the rigidity and precise adjustment of a standard bow compass, the simplicity and speed of a friction type compass, plus the finger tip control of K&E's unique design. You have to try the Quick Set to appreciate it fully. Two types are available. The N1071 fixed leg pencil compass, and the N1070 combination with interchangeable pen and pencil inserts. Both come with a box containing leads and spare needles. And with the N1070, a pen handle is provided for the pen insert which permits its use as a ruling pen. The compass can also be used as a divider by substituting one of the spare needle points for the lead in the pencil insert.



Marathon® Ruling Pens

K&E Marathon Long Line and Wide Line Ruling Pens (1092) hold an extra large ink supply – draw lines up to eight times longer than ordinary ruling pens. And because they are pre-set, line widths are always uniform, easy to match with complete accuracy. Ink flow is regular and even, lines are always sharp and clean edged.

An important feature of K&E Marathon Ruling Pens is that they will *not leak*. They can be laid on the work surface without risk of ink flowing out. That means you can fill several pens of different widths, use them as freely as you'd use pencils. They're easy to clean, too.

K&E Marathon Long Line Ruling Pens are available individually in line widths of .006, .009, .013, .020 inch – or in sets of three pens in line widths of .009, .013, .020 inch in a Leatherite case. Marathon *Wide Line* Ruling Pens come in line widths of .030 and .060 inch.

Leroy® Height and Slant Control Scriber

A versatile new Leroy scriber is now available which greatly expands the variety of lettering possible from a standard Leroy template.

Now, with the new Height and Slant Control Scriber (3237-12), you can form characters from vertical to slanting at any angle up to 45° forward. You can vary height from 60% to 150% of the size of letters on the template used. The width of letters remains the same.

Combinations of height and slant can be set quickly and easily. You just loosen the knob, move the scriber arm to the desired combination of height and slant, and tighten. That's all there is to it.

Stop in to see your nearest K&E dealer and ask to see these three products—small, perhaps, but mighty handy in the drafting room. Or drop us a line by mailing the coupon below . . .

KEUFFEL & ESSER CO., Dept. AA-7 Hoboken, N. J.

I'd like more information on:

- ☐ K&E Quick Set Compass
- ☐ Marathon Ruling Pens
- ☐ Leroy Height and Slant Control Scriber
- ☐ Please send me the name and address of my nearest K&E Dealer.

Name & Title_____

Company & Address_____

_____ 1613

Write in No. 117 on Reader Service Card as start of Product Preview Section

The Shape of Flight The shapes of things that fly have always been determined by the materials they are made of. Feathers form wings that are basically alike for all birds—and membrane forms an entirely different wing for insects. It takes thousands of years, but nature improves its materials and shapes, just as technology improves the materials and shapes of aircraft. But here the improvements in materials are so rapid that designs become obsolete almost as soon as they are functional.

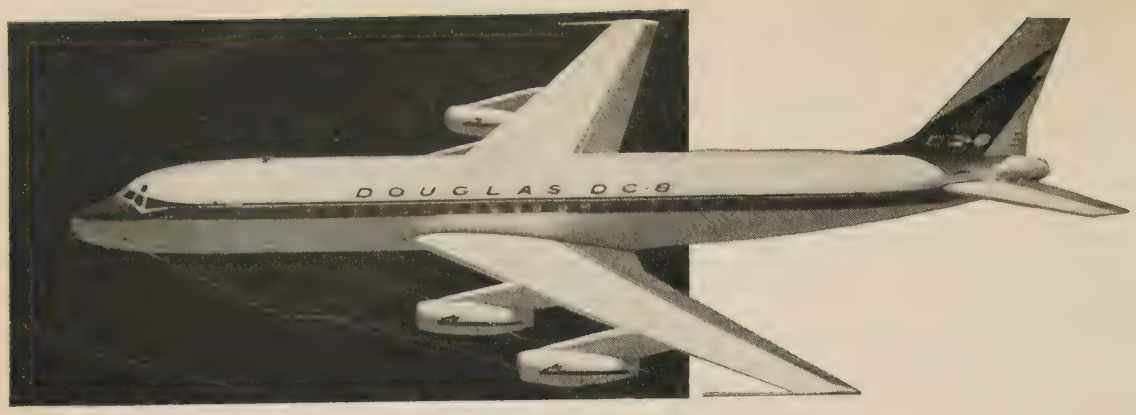
Today, the aeronautical designer has types of materials that didn't exist just a few short years ago. Steel is a good example—*five* new types have become available in the past year through USS research: USS Airsteel X-200, an air-hardenable alloy steel with 230,000 psi yield strength; USS Strux, an alloy steel with close to 300,000 psi tensile strength; USS 12 MoV and USS 17-5 MnV Stainless Steels for high speed aircraft and missiles; and USS Stainless "W", a precipitation hardenable stainless steel.

Write for complete technical information about these remarkable new materials.
United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

USS is a registered trademark

USS **United States Steel**

Write in No. 118 on Reader Service Card at start of Product Preview Section



FOR THE DC-8...A FAIL-SAFE A-C SYSTEM

weighing less than this family of 3

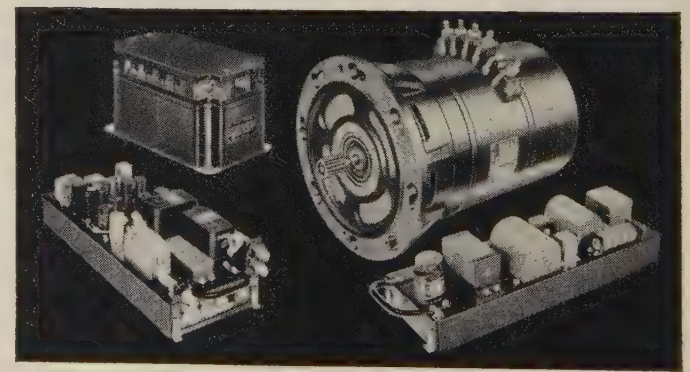
Designed by Douglas and J&H engineers, the DC-8's new a-c power system components weigh, *in total*, just 375 lbs. . . . less than many a family of three who'll board the magnificent jet liner.

This total system contains *four complete electric-power plants.* Each contains equipment ranging from the generator to the current transformers, and each represents the ultimate in reliability. All are so ideally interrelated as to win a "fail-safe" report from editors of the aviation press.

Dramatic success of the DC-8 system through all phases of its development typifies how the J&H organization handles an over-all system project. All research, development and production are conducted at *one location* for maximum teamwork, with no lost motion.

Whether your system problem is a-c or d-c . . . aircraft, missile or ground support . . . J&H has the experience and facilities to solve it for you. Check into these capabilities by writing to Jack & Heintz, Inc., 17635 Broadway, Cleveland 1, Ohio.

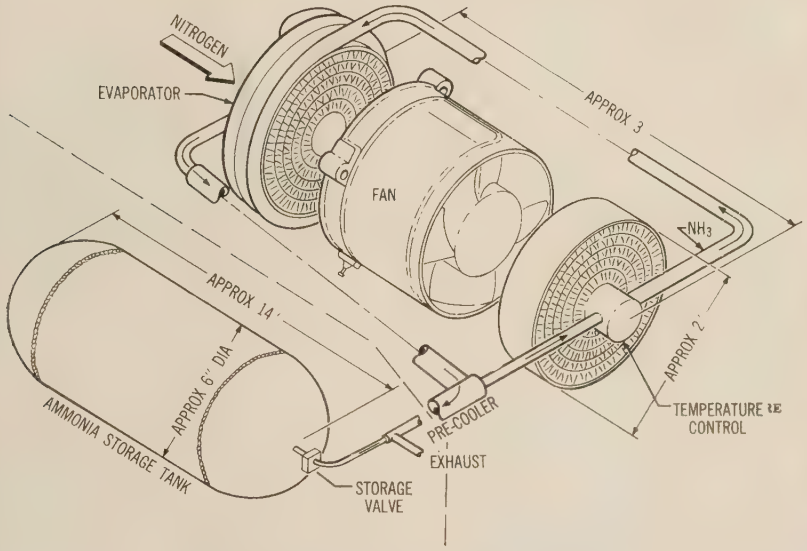
For each DC-8 engine, J&H provides regulator, generator, panel, power relay and other protective and control components.



JACK & HEINTZ, Inc.

SYSTEMS FOR AIRCRAFT, MISSILES AND GROUND SUPPORT

Write in No. 119 on Reader Service Card as start of Product Preview Section



ELECTRONIC COOLING SYSTEM

A COMPACT cooling system for electronic equipment has been developed by the Garret AiResearch Mfg. Div., 9851 Sepulveda Blvd., Los Angeles 45, Calif. It uses ammonia as an expendable evaporant to absorb heat from nitrogen gas after it has passed over the parts.

Designed to cool equipment dissipating 130 W, the system consists of ammonia storage tank, pre-cooler, evaporator, fan, and control valve. The ammonia is stored in a steel container holding five pounds and is sub-cooled by the exhaust ammonia gas as it flows through the pre-cooler.

The ammonia is throttled to ambient pressure by a control valve. From there, it passes through the evaporator where it cools the nitrogen, absorbing thermal energy from the system. The ammonia gas then passes through the pre-cooler and is dumped overboard.

Nitrogen enters the system after passing over the heat-generating components at 135 deg F. A fan draws it through the evaporator for cooling to 127 deg F. A thermostatic valve controls the flow of ammonia that absorbs the heat from the nitrogen.

The pre-cooler is an aluminum counterflow heat exchanger consisting of a 30-in.-long, ⅛-in.-OD tube. The liquid ammonia flows through the inner tube and is cooled by ammonia vapor from the heat exchanger flowing in the opposite direction through the annular space between the two tubes. As the pre-cooler sub-cools the liquid ammonia before it is throttled to ambient pressure and so superheats the ammonia vapor, the overall enthalpy change of the ammonia is increased and the total ammonia requirement is decreased.

The evaporator is a modified aluminum plate-and-fin type. The heat transfer surface of its gas side is claimed to combine high performance with low volume and weight. The axial-flow fan is powered by a 0.03-hp, three-phase, 400-cycle, 115-V motor. Circle No. 57 on Reader Service Card for more information.

QUALITY CONTROL SYSTEM

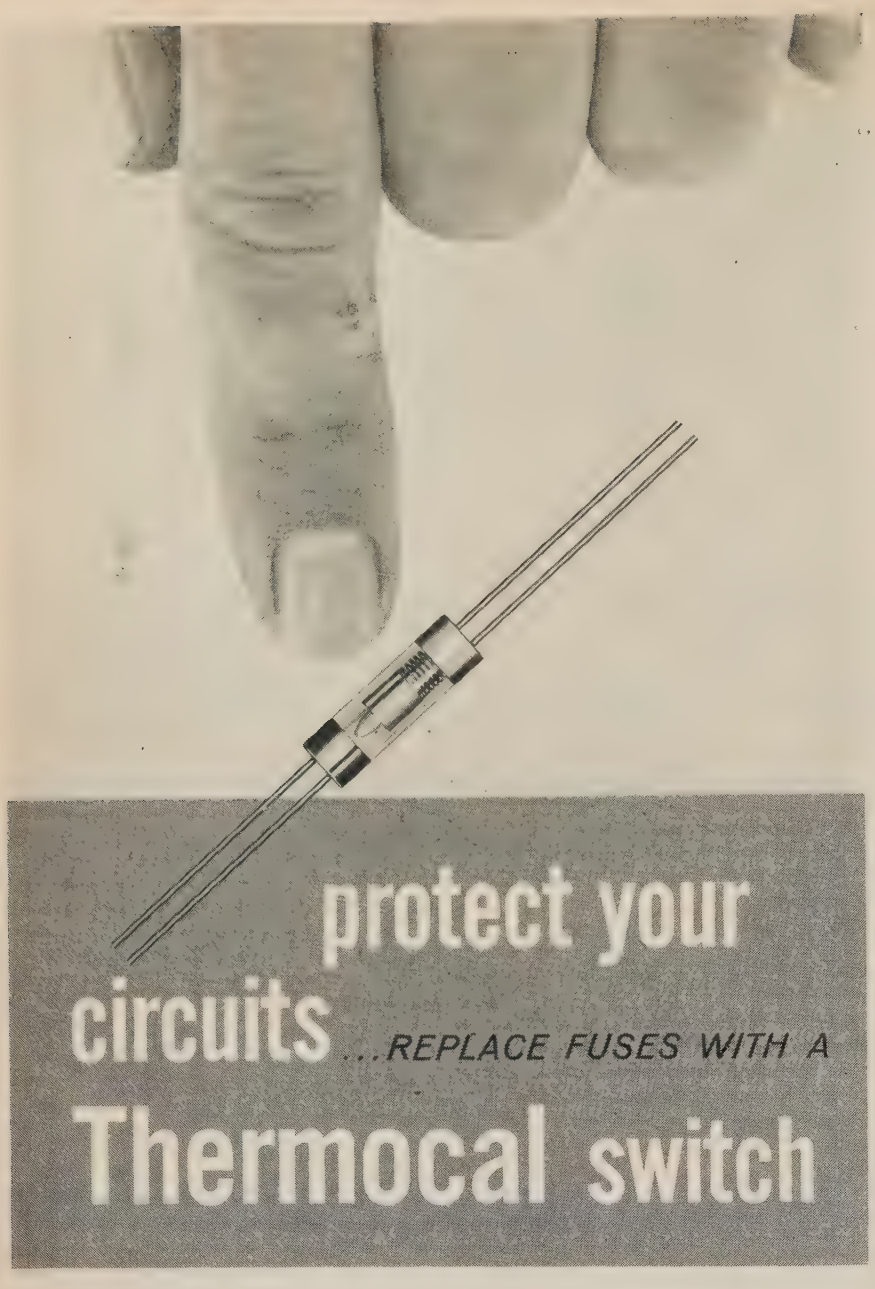
A NEW quality control system in operation less than 16 weeks is said to have reduced rejects, rework, and scrap at Lockheed Aircraft Corp., Marietta, Georgia, by as much as 50 per cent. Called "Keysort", it was developed for Lockheed by Data Processing Div., Royal McBee Corp., Westchester Ave., Port Chester, N. Y.

The deficiency report cards used by the system make it possible to pinpoint exactly where, why, and when a rejection occurs. For instance, weekly reports derived from "Keysorting" these cards showed that 51 per cent of all discrepancies fell within only nine per cent of the quality characteristics on which reports were made. In addition, it was discovered that two out of 24 work positions accounted for 60 per cent of all discrepancies. In terms of the systems of the aircraft in production at Lockheed-Marietta, two of them accounted for over 70 per cent of all discrepancies.

If a flaw is detected at any point of manufacture at Lockheed-Marietta, it is recorded on a four-part "quality control deficiency record." The form is so designed that the inspector enters only a minimum amount of information — yet enough to show exactly where and when a discrepancy occurred.

This form remains in the aircraft's control book until the reported condition has been corrected. Once that is done, the form is marked for corrective action taken, what it took to fix the discrepancy and the time spent in making the fix. The four-part form is then split up, with one copy going to the group responsible for the deficiency, one to the inspecting department, one into the aircraft's records, and one to Quality Control. Circle No. 58 on Reader Service Card for more information.

more on next page



PYRISTOR®...*protects your equipment circuitry...precisely*

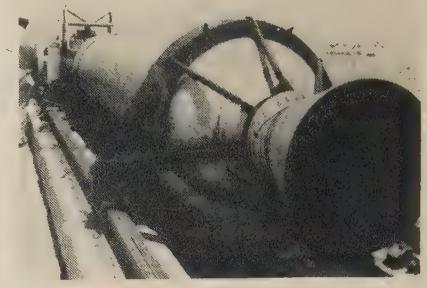
NEW miniature, hermetically sealed, single-shot, current-sensitive switch for positive overload protection and for current operated triggering devices.

RELIABILITY *in critical environments*
...from −100° F. to +1000°F. continuous.
...closing time 1 millisecond to 5 seconds.

Write for new Brochure containing complete specifications.
advanced concepts of precision specialty switches for maximum protection

thermocal
1631 COLORADO AVENUE
SANTA MONICA, CALIFORNIA

Write in No. 120 on Reader Service Card at start of Product Preview Section



FIELD-LOADED SLED ROCKETS

TAKING off from its Megaboom engine, Astrodyne, Inc., P. O. Box 548, McGregor Texas has come up with a basic design for solid propellant test sled rockets whose thrust could be varied in the field. The propellant charge would be assembled and loaded by the track operator after figuring out the propulsion needs for a specific run. Field loading of rockets range from 6500 to 300,000 lb in thrust and from 3.5 to 15 seconds in duration would be possible.

The Megaboom features Astrodyne's modular propellant grain design in which a series of extruded ammonium nitrate segments is suspended on longitudinal steel rods and supported within the rocket case by perforated steel plates. The same modular approach is used for the field-loading concept.

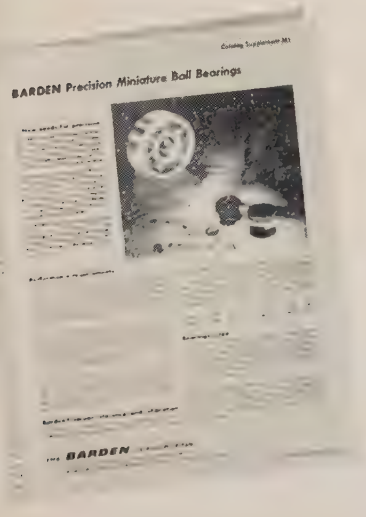
A supply of nozzles and propellant bundles of various sizes would be made available to the user. Typical propellant segments would include curved and straight slabs, regular and sliverless cogs, single- and triple-perforation triforms, and curved T-shapes. Templates or other devices would be used to identify the correct selection of propellant, charge weight, and nozzle design for specific applications.

The modular design lends itself readily to runs at varying G-rates. The burning rate and the web thickness of certain grains or banks of propellants can be changed in advance to produce a given thrust. Similarly, thrust that trails off slowly at burnout or drops off sharply can be furnished by controlling the sliver content. Circle No. 62 on Reader Service Card for more information.

Write in No. 128 on Reader Service Card

Barden Precision SFRI-5 miniature bearings as used in a computer gear train.

Specify **BARDEN** *Precision miniature ball bearings*



Precision-built computer gear trains must have uniformly low torque and minimum backlash; mounting surfaces for the bearings should be simple to manufacture.

Barden Precision miniature-size bearings have the required low torque. Their low eccentricity and closely controlled radial play assure minimum backlash. Precision flanges provide accurate positioning surfaces and permit through-boring, eliminating the need for housing shoulders.

Barden Precision miniature bearings are built to the same high standards of consistent quality as Barden's larger instrument sizes.

Barden Precision means not only dimensional accuracy but performance to match the demands of the application.

Your product needs *Barden Precision* if it has critical requirements for accuracy, torque, vibration, temperature, or high speed. For less difficult applications, the *predictable* performance of *Barden Precision* bearings can cut your rejection rates and teardown costs.

Write today for your copy of Catalog Supplement M1 which gives dimensions, performance and engineering data on *Barden Precision* ball bearings 5/8" O.D. and smaller.

THE BARDEN CORPORATION

75 E. Franklin St., Danbury, Connecticut • Western office: 3850 Wilshire Blvd., Los Angeles 5, California

SPECIFY BARDEN PRECISION BALL BEARINGS FOR: INSTRUMENTS • AIRCRAFT ACCESSORIES • COMPUTERS AND RECORDERS • MACHINE TOOL AND TEXTILE SPINDLES • OTHER PRECISION APPLICATIONS

HOW SAC's "HOUND DOG" SCENTS ITS TARGET

The crew of the B-52G starts up the jet engine of the sharp-nosed GAM-77 Hound Dog missile hung under its wing... gives its inertial autonavigator the location of the target.

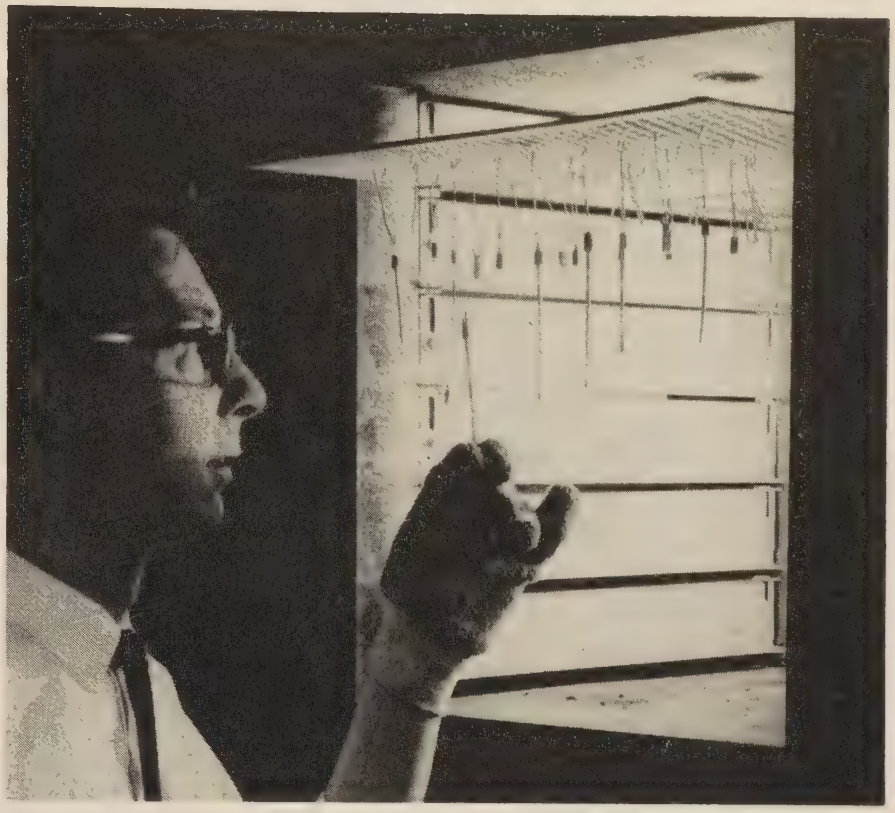
On a "for-real" mission, the Hound Dog would leap toward its target at supersonic speed—very likely a ground-defense center hundreds of miles away. Its guidance system can't be jammed... can't be decoyed.

Purpose of the GAM-77 air-to-ground jet-powered guided missile is to increase the striking power of Boeing's B-52. Sling a pair of Hound Dogs under the wings of the new B-52G—and you have what amounts to a brand-new weapon system.

The GAM-77 program was started in August, 1957. The missile has been put into accelerated development. It already is in its early flight test phase... will be deployed by 1960.

Weapon system contractor: the Missile Division of North American Aviation.

MISSILE DIVISION NORTH AMERICAN AVIATION, INC., DOWNEY, CALIFORNIA



HIGH TEMPERATURE TERMINAL speeds systems installation

Feature Product Award

JUNE 1959

The Thomas & Betts Co., 36 Butler Street, Elizabeth, N. J., has developed the first self-insulated electric terminal for high temperature applications in aircraft and missile wiring. According to the company, the terminal is a highly significant contribution to systems installation. A single-piece design, it is installed in less than half the time it takes to install the normal two-component terminals. As a result, there can be substantial savings in labor costs even when only a small number of terminals are to be installed.

The terminal uses Teflon as the sleeve material, which covers the terminal barrel and a portion of the conductor to be terminated. The Teflon allows use at up to 500 deg F for indefinite periods and up to 600 deg F for short periods. The intimate contact between wire and terminal remains permanent despite constant high temperatures.

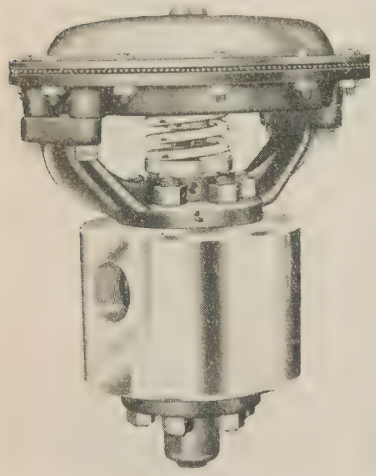
Write in No. 122 on Reader Service Card

This award is made in recognition of outstanding service performed through the development and manufacture of a product contributing to the advancement of the aerospace industry.

Randolph Hawthorne
Editor

product preview

AIR CONTROL VALVES for missile test stands



These 5,000 psi, screw-mounted, diaphragm-operated air control valves, for precise control of ultra-high pressure air on missile test stands and similar applications are said to afford smooth, shockless opening and closing at maximum rated pressure, plus fast response and leak-free operation. Sleeve-type construction with aluminum bronze billet or alloy steel bodies. A replaceable hardened stainless steel seat sleeve insert in the valve body maintains constant, precise alignment of valve stem and seats, it is claimed by **Sinclair Collins Valve Co., Dept. S/A, 454 Morgan Ave., Akron 11, Ohio.**

The valves are offered in 2 and 3-way types, NO or NC. in ½ and ¾ in. NPT sizes.

Write in No. 213 on Reader Service Card

CASTER will handle 1000 lb

This shock absorbing caster for handling missile and aircraft components, ceramics, liquids, delicate assemblies or other fragile loads is drop-forged steel. This new "Cush-N-Aire" line has pneumatic tires of 8", 10", 12", 14", and 16" sizes. Casings are 4-ply with separate innertubes. Bolted hubs permit fast tire demounting and remounting. Wide base rims. Load capacities range up to 1000 lbs. for each caster, says **Hamilton Caster & Mfg. Co., Dept. S/A, 1700 Dixie Highway, Hamilton, Ohio.**

Construction features include integrally forged kingpin, Timken tapered thrush bearing, and slotted cotter pin nut for precise adjustment of swiveling action.

Write in No. 214 on Reader Service Card

MERCURY SWITCH is highly sensitive

This low-angle mercury switch, AS603A1, is designed to meet the precise requirements of vertical gyros, stable platforms, and rocket guidance systems. It weighs 3.8 grams, including three 7-inch Teflon-insulated leads. It features a differential angle of .15 degrees maximum and a mass shift of .085 grams-centimeter, which, says **Micro Switch Div., Minneapolis-Honeywell Regulator Co., Dept. S/A, Freeport, Ill.,** makes it the "most sensitive mercury switch ever developed."

Hermetic sealing of the glass tube prevents dust, dirt and corrosive vapors from fouling contacts. Contact arrangement is single-pole, double-throw.

Write in No. 215 on Reader Service Card

ANCHOR BUSHINGS for drill templates

This Press Type Anchor Bushing provides a simple, quick and inexpensive method for making drill templates. It is pressed into drilled or punched holes in .060 or thicker aluminum template material. The double row of serrations at the base of the bushing body provides a positive lock into the template material to resist drill torque, says **Hi Shear Rivet Tool Co., Dept. S/A, 2600 W. 247 St., Torrance, Calif.**

Drill sizes #55 (.052) through 7/16 (.4375) are accommodated by only three bushing pilot sizes.

Write in No. 216 on Reader Service Card

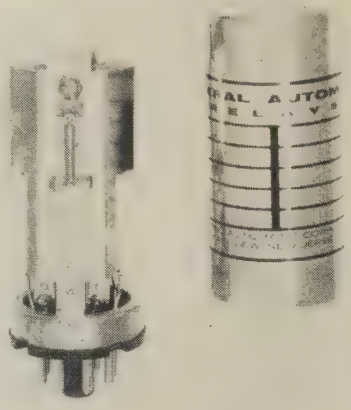
SYNCHROS meet new Mil specs

These units offer improved accuracy and environmental characteristics, higher torque gradients, and lower nulls, says **United Aircraft Corp., Morden Div., Dept. S/A, Commack, N.Y.**

Synchro receivers, transmitters, and differentials for both torque and control systems are available. Frame sizes from 08 to 23 have been designed for 400- and 60-cps applications. These units are manufactured and tested in accordance with Mil-S-20708 and are reportedly the only units approved by the Navy Bureau of Ordnance.

Write in No. 217 on Reader Service Card

RELAY is dust-proof



This small dust proof relay has a sensitivity as low as 2 milliwatts per contact in contact combinations from SPST to DPDT. Series 100 types standard enclosure is a round aluminum protective dust cover with a removable bayonet cover or the cover crimped to base. The removable cover permits easy inspection or adjustment with a screw driver to modify pick-up characteristics, contact pressures or power requirements. Specifically designed for commercial and military applications requiring low unit cost but a high degree of operating reliability, says **General Automatic Corp., Dept. S/A, 12 Carlton Ave., Mountain View, Waynes, N. Y.**

The relays can be adjusted with pick-up and drop-out ratios as high as 85% or as low as 10%.

Write in No. 218 on Reader Service Card

EXPANSON JOINTS absorb any movement

These bellows-type Zallea expansion joints accommodate pipe movement in any direction. They are packless, corrugated-bellows units that protect power and process piping systems by absorbing axial movement, lateral deflection and angular rotation, either singly on in combination. Absorption of unlimited amounts of lateral deflection without imposing any pressure thrust on piping or equipment eliminates the need for heavy structural anchors, says **Zallea Brothers, Dept. S/A, Wilmington, Del.**

Basic elements include two hydraulically-formed bellows, a center section of pipe and appropriate tie rods. Standard sizes from 3" to 72" diameter, are supplied with one of three different types of bellows.

Write in No. 219 on Reader Service Card

more on page 182

for Communications

on the Missile Base Complex...

come to the experts!

DuKane electronic communication systems provide the vital network of instant voice communication which literally ties together such installations as Fort Churchill, Patrick AFB, and White Sands. DuKane offers the broadest, most flexible, most versatile line of custom-installed communication systems in the industry. For an installation involving a few persons, or hundreds, DuKane's experts can help you design and specify a communication system which will fill your needs. Why not ask for their help? *Write or wire DuKane Corporation, Dept. SA-3, St. Charles, Illinois*

If you specify electronic equipment, ask also for DuKane's chart of electronic equipment symbols.

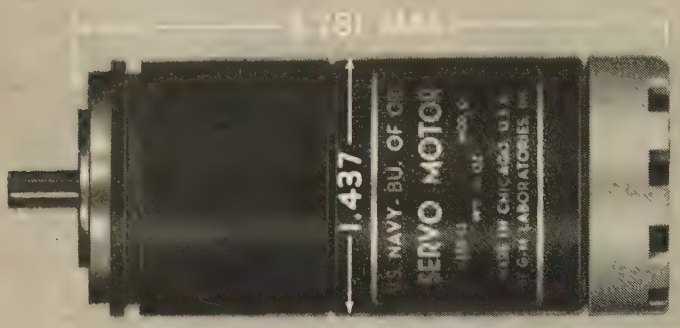
DuKane Products are installed and serviced by a nationwide network of factory-trained experts

DuKane CORPORATION
St. Charles, Illinois

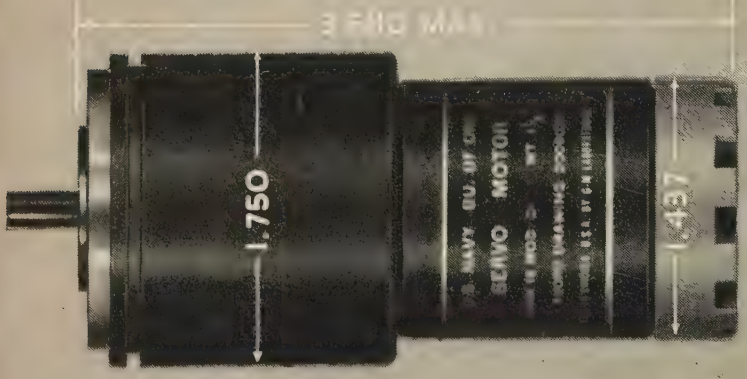
Job-engineered sound installations . . . Flexifone intercom systems . . . Private automatic telephone systems . . . Hospital communications systems . . . Ionovac hi-fi tweeters and ultrasonic generators . . . Sound slidefilm projectors for education and industry . . . Electronic production facilities for industry and for defense.

Write in No. 123 on Reader Service Card at start of Product Preview Section

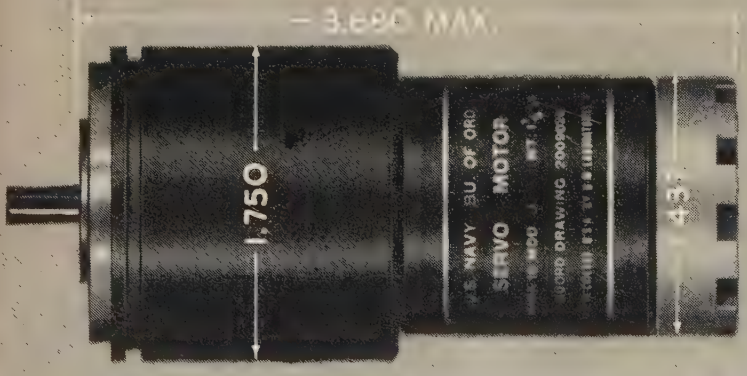
3 More GM Servo Motors



BuOrd Mark 12 Mod 0 SERVO MOTOR Tachometer
Generator 115 volts / phase, 4500 RPM (min).



BuOrd Mark 16 Mod 0 SERVO MOTOR Tachometer
Generator 115 volts / phase, 4500 RPM (min).



BuOrd Mark 16 Mod 3 SERVO MOTOR Tachometer
Generator for transistor operation 115 volts fixed phase 36/18 volts control phase, 4500 RPM (min.)

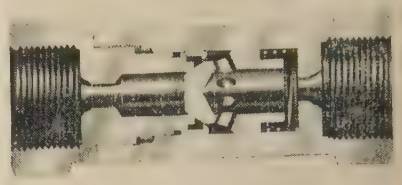
GM
G-M Servo Motors
manufactured by the Components Division of
G-M LABORATORIES INC.
4306 N. Knox Avenue • Chicago 41

Built to all applicable Government Specifications—in production . . . available for prompt delivery.

For complete information on these and all SERVO MOTORS, write for G-M PROCUREMENT SPECIFICATION NO. 665.

Write in No. 124 on Reader Service Card at start of Product Preview Section

CHECK VALVE *for liquids and gases*



This heavy duty check valve for high pressure gas services to 10,000 psi and is equally suitable for high pressure liquid services. A safety factor of 4, and the novel means of retaining the seat, make it particularly applicable for high flow, heavy surge applications, says **Republic Mfg Co., Dept. S/A, 15655 Brookpark Rd., Cleveland 35, Ohio.**

Metal parts are stainless steel. Choice of Teflon or synthetic rubber seals.

Write in No. 220 on Reader Service Card

TANTALUM CAPACITOR *resists shock and vibration*

Type PP tantalum capacitor has been improved by a specially designed anode-base support which gives it exceptional resistance to shock and vibration, says **Fansteel Metallurgical Corp., Dept. S/A, North Chicago, Ill.**

The unit is electrically stable over a range of operating temperatures from —55 to +85 deg C. The capacitor consists of a sintered porous tantalum anode, hermetically sealed in a silver case which serves as a cathode and container for the electrolyte.

Write in No. 221 on Reader Service Card

MASS FLOW TOTALIZER *for gases*

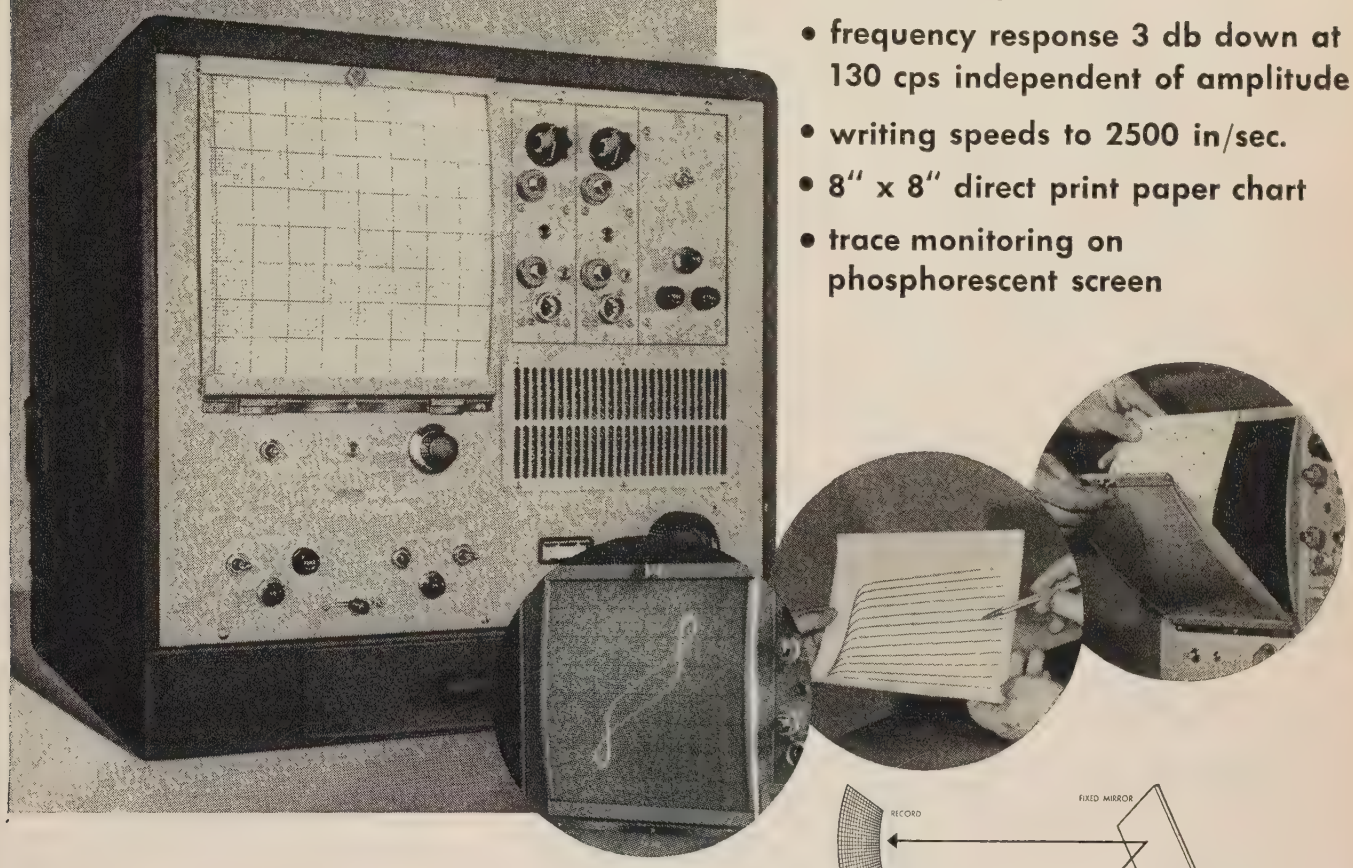
This digital inertial mass flow measurement system for high pressure gases measures flow directly in pounds and displays in digital form either totalized mass flow or mass flow rate, or both. The range covered by "Extended Range Digimaf" is .07 to 7 pounds per second at pressures up to 6000 psig over a temperature range of —100° F to +250° F. Overall accuracy for either totalization or flow rate indication is ± 2% of total reading. Operates interchangeably with various gases and with gaseous mixtures of unknown constituency. No corrections or computations required for changes in gas density. No error is incurred due to non-ideal gas compressibility, says **Inertial Instruments, Inc., Dept. S/A, 1738 Colorado Ave., Santa Monica, Calif.**

The equipment consists of 6000 psig transducer, a servo amplifier, and a digital totalizer.

Write in No. 222 on Reader Service Card

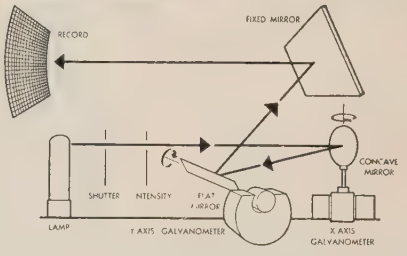
more on page 184

100 CPS X-Y RECORDING with immediate readout



THE NEW SANBORN MODEL 670 OPTICAL X-Y RECORDER HAS

- 1% linearity
- frequency response 3 db down at 130 cps independent of amplitude
- writing speeds to 2500 in/sec.
- 8" x 8" direct print paper chart
- trace monitoring on phosphorescent screen



X-Y RECORDING never before possible with electro-mechanical instruments can now be done with the new Sanborn Model 670 X-Y Recorder. Direct writing on ultraviolet-sensitive recording paper by a beam deflected by optical galvanometers makes possible the combination of fast writing speed and 130 cps frequency response not found in any other X-Y recorder. Transistor characteristics, acceleration and vibration of mechanical parts and events of similar short duration can be recorded with linearity of *1% of full-scale* and at trace speeds as fast as *2500 inches per second*. Square wave response exhibits no greater than ½% overshoot *at any amplitude;* sensitivities as high as 62.5 uv/inch (depending on preamplifier used).

PLOTS OCCUPY AN 8" x 8" RECORDING AREA and can be previewed or monitored on the instrument's phosphorescent screen. An Axis Record switch to print X and Y axes on the record, and a Beam Intensity Control to assure maximum trace clarity, are among the front panel controls provided. An 8" x 8" sheet of the ultraviolet-sensitive chart paper (stored in drawer at base of cabinet) is easily placed on the back of the hinged screen. Brief post exposure in normal room light is the only developing process.

OPTIONAL INTERCHANGEABLE PREAMPLIFIERS for each axis presently include the Model 850-1300B DC Coupling and Model 850-1200 Phase Sensitive Demodulator; a Carrier Preamplifier, High Gain Preamplifier and a time base generator are now in development. Driver Amplifiers are compact, fully transistorized plug-in units with single-ended input and output. Galvanometers are low resistance, low voltage units of rugged, enclosed construction; sensitivity and damping are independent of coil temperature. Accessible, unitized circuitry also extends to the power supplies—a front-panel plug-in for both preamplifiers and a second supply for both driver amplifiers. A built-in blower provides constant, forced filtered air cooling. The Recorder can be rack mounted in 15¾" of panel space, or housed in its own 20" x 20" x 21¼" optional portable cabinet.

Ask your local Sanborn Sales-Engineering Representative for complete information on the Model 670 X-Y Recorder, or write the Industrial Division in Waltham, Mass.

SANBORN COMPANY

INDUSTRIAL DIVISION

175 WYMAN STREET, WALTHAM 54, MASS.

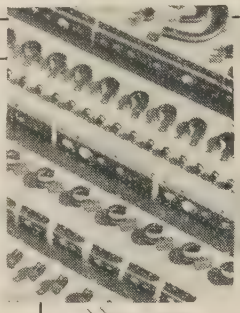
Write in No. 125 on Reader Service Card at start of Product Preview Section

ADEL LINE SUPPORTS

designed for every application

CLAMPS · BLOCKS · HARNESS STRAPS

for military & industrial systems & equipments



They cut maintenance and replacement costs . . . performance and reliability far beyond specifications of any other Line Support.

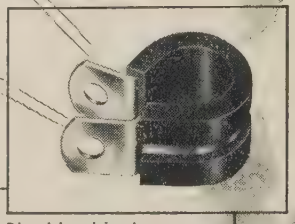
CLAMPS provide cushioned, vibration absorbing support for cables, tubing and piping.

BLOCKS provide resilient support for multiple grouping of lines to eliminate failures.

HARNESS STRAPS embody heat and cold resistant material for temperatures far above +550°F to well below −90°F.

For safety, flexibility, durability and economy SPECIFY ADEL and be certain of getting the best possible service from products that are the result of advanced engineering design and the most modern production techniques.

A COMPLETE LINE . . . SERVICE-FITTED, TESTED AND APPROVED. SPECIFICATIONS ARE AVAILABLE TO AIRCRAFT, MISSILE AND ORIGINAL EQUIPMENT MANUFACTURERS . . . WHAT ARE YOUR REQUIREMENTS?



Reliability

ADEL PRECISION PRODUCTS

A DIVISION OF GENERAL METALS CORPORATION

DISTRICT OFFICES: Burbank • Mineola • Dayton • Wichita • Dallas • Toronto

Direct inquiries to
Huntington Division
1444 Washington Ave.,
Huntington 4,
West Virginia

Write in No. 126 on Reader Service Card at start of Product Preview Section

500 WATTS IN FIVE CUBIC INCHES!

Shown Actual Size

. . . a brand new proportional amplifier only 5 cubic inches in size and .54 lbs. in weight—for missile, aircraft, and ground equipment applications. A 400 cps, 115 volt proportional temperature control unit using silicon control rectifiers in the output stage, it handles up to 500 watts power. Maximum ambient temperature capability of 100°C!

It's exclusive—available now—and ready to solve your space, weight, and power problems!

Write today for complete information:

MAGNETIC CONTROLS COMPANY

6405 Cambridge Street, Minneapolis 16, Minnesota, Dept. 101

Write in No. 127 on Reader Service Card at start of Product Preview Section

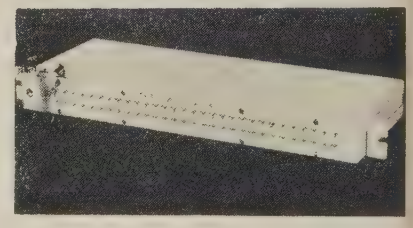
CONNECTORS are vacuum-tight

A series of 5039 vacuum-tight flexible connectors isolate vacuum systems from vibration caused by mechanical pumps and other sources and also facilitate assembly of vacuum systems employed in refining and fabrication of high performance metals, vacuum coating, freeze drying, distillation, evacuation, high altitude simulation, leak testing, and other laboratory and industrial processes. They are available in 2″ to 6″ and 10″ pipe size, says **NRC Equipment Corp., Dept. S/A, Newton, Mass.**

Each connector consists of a stainless steel bellows and two flanges, one of which (except the 10″ size) is constructed to facilitate assembly of two components which may have different bolt hum orientation.

Write in No. 223 on Reader Service Card

DELAY CHASSIS is compact



Model DU-10 contains 30 separate electrical one-microsecond delay lines conveniently packaged in a standard 19x1-¾ in. rack-mounting chassis. The lines can be used separately or joined in series by simple taper pin jumper connections to form the desired total delay, says **Computer Control Co., Inc., Dept. S/A, 92 Broad St., Wellesley, Mass.**

The basic one-microsecond delay interval per line, accurate to within ±2%, can be used directly with other Series T digital modules. Upper cutoff frequency is 5.6 mc. Characteristic impedance is 91 ohms. Attenuation is 1 db per microsecond of delay.

Write in No. 224 on Reader Service Card

ASTRODOMES for tracking equipment

Instrumentation, cameras, telescopes, etc., used in tracking missiles are protected from the elements by this astrodome using insulated sandwich construction of impregnated honeycomb covered with fiberglass. It is airtight and weatherproof, says **Houston Fearless Corp., Dept. S/A, 11817 W. Olympic Blvd., Los Angeles 64, Calif.**

The viewing aperture is power-driven for quick action. The dome rotates on the base cylinder.

Write in No. 225 on Reader Service Card

more on page 186

Jewels by Janitrol

If you are concerned with utilization, distribution, and control of high temperature, high pressure air for canopy seal, tank pressurization, fuel transfer, or any other interesting aircraft or missile application, this picture will interest you.

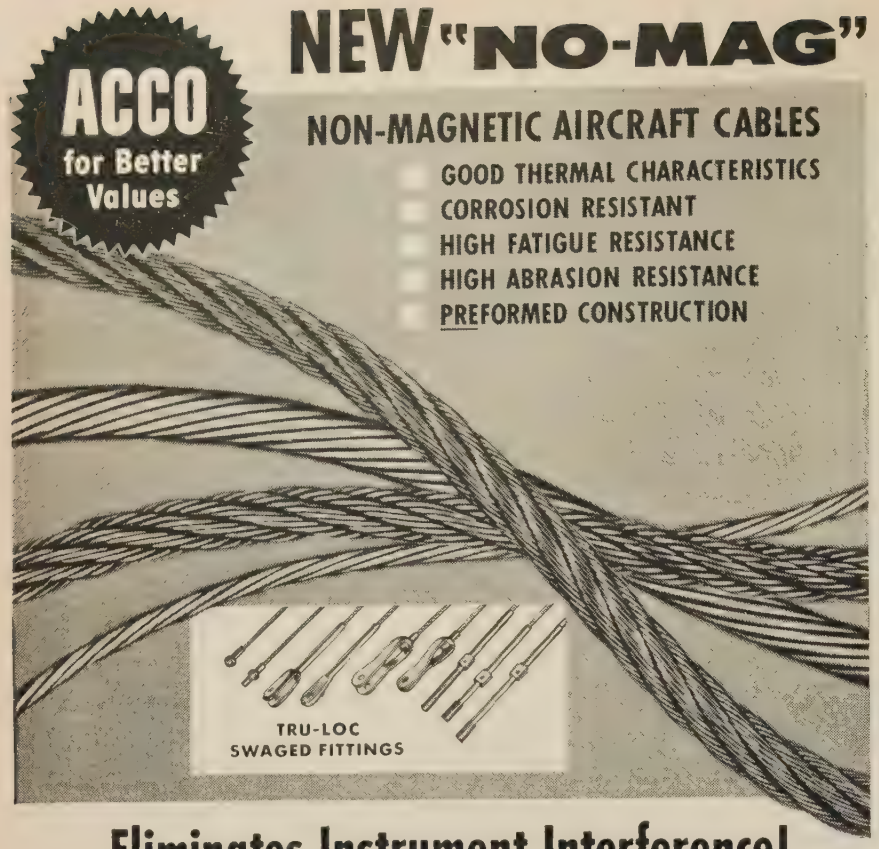
It shows an important facet of Janitrol's capabilities in the design and production of precision valves whose refinements and tolerances call for a jeweler's approach. The large family of Janitrol valves offers convincing evidence of our exceptional problem solving abilities in a field where reliability requirements are constantly being raised.

A complete picture of our capabilities is presented in a new brochure "Janitrol Resources." For your copy ask your nearest Janitrol engineering representative, or write: Janitrol Aircraft Division, Surface Combustion Corporation, Columbus 4, Ohio, BRoadway 6-3561. Also: Ft. Worth, WAlnut 6-3386; Hollywood, HOllywood 3-6861; Washington, D. C., OLiver 4-2171; Philadelphia, MIdway 2-6342.

pneumatic controls • duct couplings and supports • heat exchangers • combustion equipment for aircraft, missiles, ground support

JANITROL®

Write in No. 121 on Reader Service Card at start of Product Preview Section



Eliminates Instrument Interference!

• Just as we expected, many aircraft designers were interested in the recent announcement of our new non-magnetic aircraft cable. If you did not see it, "NO-MAG" has these characteristics:

NON-MAGNETIC PROPERTIES . . . "NO-MAG" cable is made from type 305 stainless steel. It remains non-magnetic after severe cold working —in contrast to standard stainless steel aircraft cable which shows a pronounced increase in magnetism after swaging, wire drawing or similar operations.

This non-magnetic property of "NO-MAG" cable eliminates instrument interference from cable magnetism.

CORROSION RESISTANCE . . . New "NO-MAG" cables have corrosion-resistant qualities similar to, but slightly better than, cables made of standard stainless steel.

GOOD THERMAL CHARACTERISTICS... The thermal expansion characteristics of new "NO-MAG" cable are much closer than those of standard stainless steel or carbon steel cables to the characteristics of aluminum alloys used in aircraft. This greatly simplifies maintaining cable tension under various changes in temperature.

HIGH FATIGUE RESISTANCE . . . Preformed construction and careful processing give new "NO-MAG" cable high fatigue resistance.

HIGH ABRASION RESISTANCE . . . New "NO-MAG" cable shows greater abrasion resistance than standard stainless steel aircraft cables.

TENSILE STRENGTH, while lower than that of stainless and carbon steel, is sufficient to enable replacing these, size for size, with "NO-MAG" on many applications where the characteristics of "NO-MAG" are required.

USE WITH SWAGED TERMINALS . . . Swaged terminals can be applied to standard AN dimensions.

COMPLETE RANGE OF SIZES, CONSTRUCTIONS . . . New "NO-MAG" is furnished in sizes from 1/16" to 1" in all of the standard aircraft cable constructions.

Get the complete story on this new technical development for the aircraft industry. Write today to Detroit office.

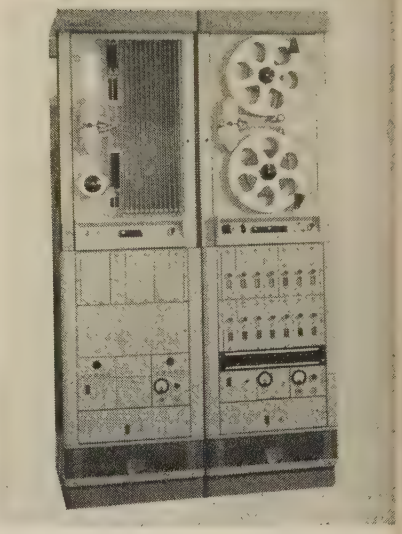
Automotive and Aircraft Division
AMERICAN CHAIN & CABLE

601 Stephenson Bldg., Detroit 2
6800 East Acco Street, Los Angeles 22 • Bridgeport 2, Conn.

ACCO
TRADE MARK

Write in No. 129 on Reader Service Card at start of Product Preview Section

RECORDER-REPRODUCER is self contained



Type 5-781 tape loop recorder-reproducer is designed for the repetitive study of highly transient data, random occurrences, and time-delay application. The unit, a completely self-contained system containing amplifiers, precision-frequency power supplies, and blower, provides selective or simultaneous erase for its 14 analog, FM, or PDM record-reproducer channels, says **Consolidated Electrodynamics Corp., Dept. S/A, 300 N. Sierra Madre Villa, Pasadena, Calif.**

It is designed to record or reproduce data on continuous magnetic tape loops of variable lengths, ranging from 2 to 75 ft., at tape speeds from 1⅞ through 60 ips.

Write in No. 226 on Reader Service Card

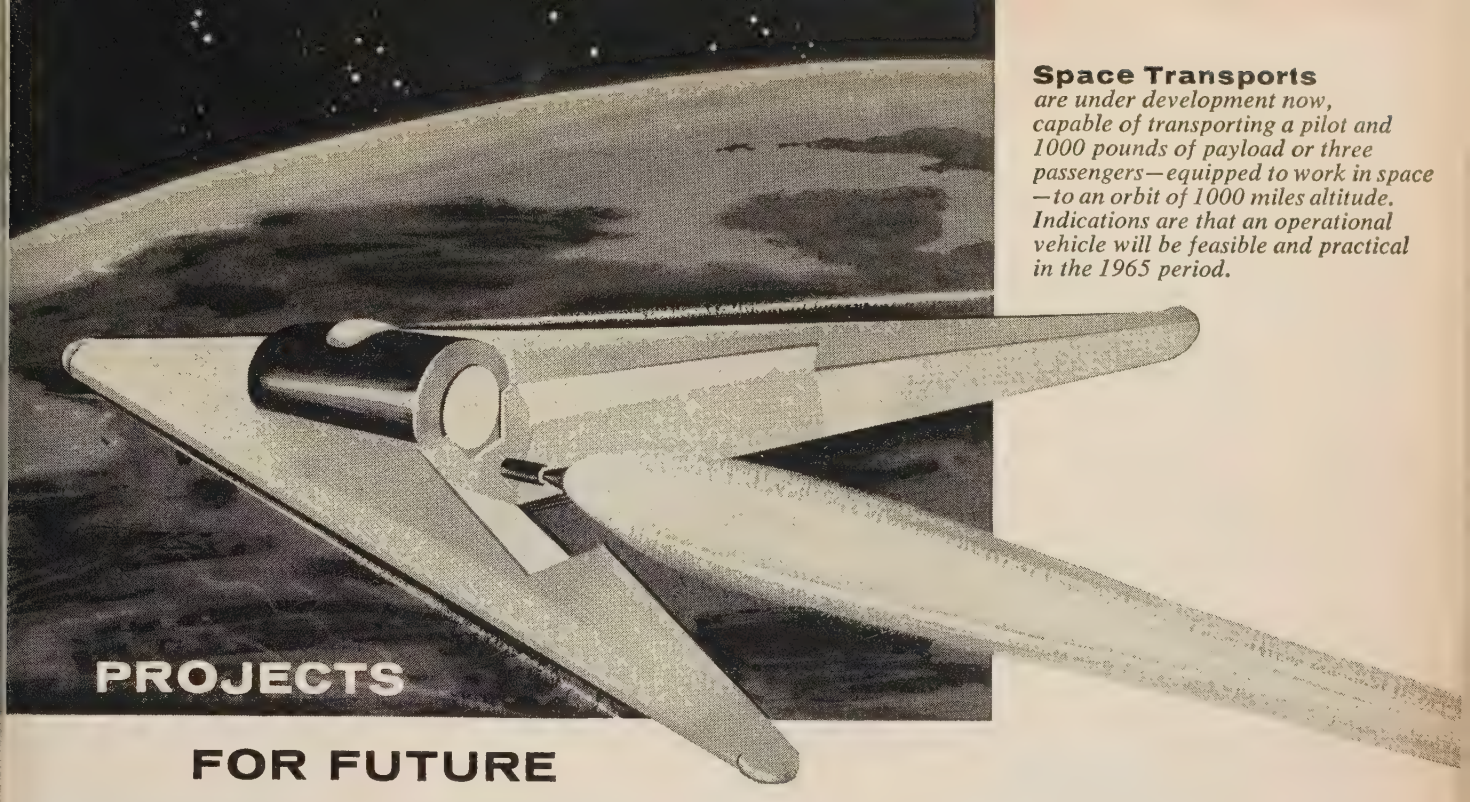
POWER UNIT for speech beacon

Extended battery storage life, increased reliability and greater economy are rovided by the RB.61 transistor power unit for the SARAH speech beacon, according to **Ultra Electric, Ltd., Dept. S/A, Western Ave., Acton, London, W.3, England.** The power unit, along with a long-life six-V battery, replaces two batteries previously used by the search and rescue device for ht and lt voltages.

The equipment is designed to maintain maximum operational efficiency in the face of severe altitude, water immersion, shock and vibration conditions. Operational temperature range is −40 to +55 deg C. The six-V battery has 24 Mercury (Kalium) type cells in a hermetically-sealed metal canister. The battery will operate for up to 23 hrs, depending on temperature, and shelf life is about two years.

Write in No. 227 on Reader Service Card

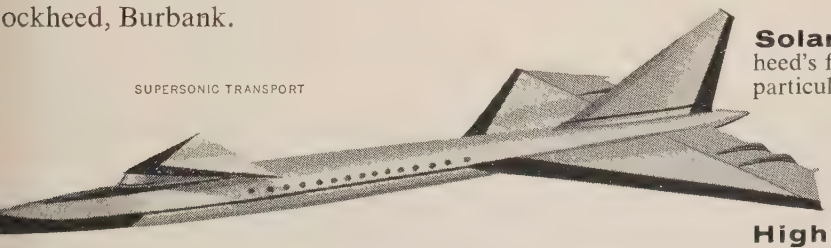
more on page 188



Space Transports
are under development now, capable of transporting a pilot and 1000 pounds of payload or three passengers—equipped to work in space —to an orbit of 1000 miles altitude. Indications are that an operational vehicle will be feasible and practical in the 1965 period.

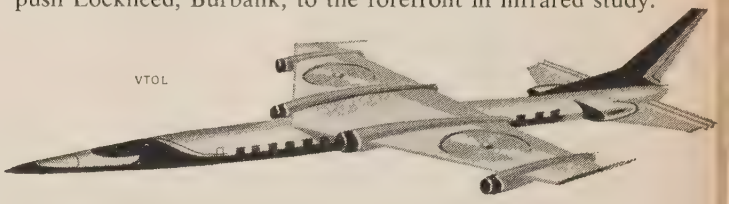
FOR FUTURE DECADES IN SPACE... *another Lockheed Progress Report to Engineers*

lotting the nation's future space exploration projects :quires the capabilities of a forward-looking company; ıe with vision, superiority in technical skills and advanced .cilities. Lockheed, Burbank, long a leader in extending ıe science of flight, is placing its vast resources and accu-ıulated knowledge into programs designed to provide ıajor breakthroughs in the fields of: Basic and applied :search; manned aircraft of advanced design; missiles and ɔacecraft. Shown here are artists' renderings of a few of ıese important projects. Such project diversification calls ɔr high-level technical skill, offers genuine challenge to xperienced engineers. At Lockheed these varied projects equire engineers in many fields. Take advantage of this eed. Go forward with a forward-looking company: ockheed, Burbank.



upersonic Transports—have held an important place our thinking for the past several years. Extensive wind tunnel sts have been conducted on many design concepts, supplemented y exhaustive laboratory and structure studies. Lockheed is pre-ıred to build an airliner that will travel at speeds in excess of ach 3 at an altitude of 75,000 feet.

Infrared Systems studies are being conducted using an advanced method of detecting fast-moving missiles and high-speed aircraft. A new facility, which includes an advanced laboratory, with an infrared tunnel, for basic research and development of prototype equipment in this expanding field, has been set up to push Lockheed, Burbank, to the forefront in infrared study.



Vertical Take-off and Landing Projects—Lockheed, Burbank, is engaged in exploring the potential of VTOL projects on a very broad scale. Different VTOL features are embodied in each proposal. Considerable emphasis is being placed on VTOL "air recovery" vehicles, designed for air rescue and reentry missiles recovery missions.

Solar Radiation Studies—are being conducted at Lockheed's flight test radio station at Briar Summit, California, placing particular emphasis on solar flares as our contribution to the International Geophysical Year. We have already accumulated more than a quarter of a million images of the sun for analysis. In cooperation with other companies, we will determine the processes by which solar energy is released.

High caliber scientists and engineers are invited to take advantage of Lockheed's outstanding career opportunities. Openings now exist in: Electronics; aero and thermodynamics; propulsion; servo-mechanisms; materials and processes; structures and stress; operations research; research in optics, infrared, acoustics, magnetohydrodynamics, instrumentation, mechanics and hydraulics; mathematics; and in all phases of design. Write today to: Mr. E. W. Des Lauriers, Manager Professional Placement Staff, Dept. 1907, 2400 North Hollywood Way, Burbank, California.

LOCKHEED / CALIFORNIA DIVISION • BURBANK, CALIFORNIA

Check Employment Inquiry Form on Page 157

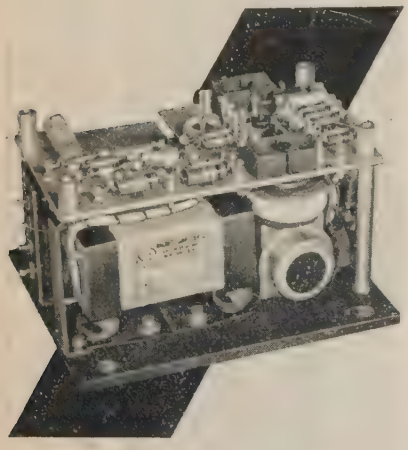
New PRECISION FREQUENCY

STATIC INVERTER SUPPLY

INPUT 28V D.C. ± 10%
OUTPUT *Nom.* 115V ± 2%
400 CPS ± 0.01%
1 Ø (2- or 3-phase output available)
RATINGS: 30VA 50VA 100VA
Higher ratings available.

APPLICATION:

For gyro wheel supplies and where precise 400 cycle voltages are required in aircraft, radar and missile computers.



FEATURES:

PRECISION OUTPUT FREQUENCY
RUGGED
EXCELLENT WAVEFORM
SIMPLICITY OF CIRCUITRY
FAST STARTING TIME
GOOD VOLTAGE REGULATION
throughout an adjustable range
ISOLATED CASE DESIGN
HIGH RELIABILITY
VIBRATION ISOLATED
COMPACT
LIGHTWEIGHT
MILITARY SPECIFICATIONS

(Send for Bulletin S-864)

MA

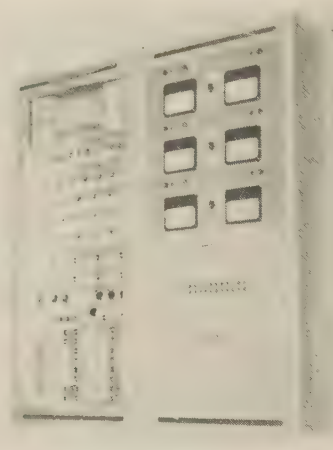
MAGNETIC AMPLIFIERS, INC.

632 TINTON AVENUE • NEW YORK 55, N.Y. • CYPRESS 2-6610

West Coast Division
136 WASHINGTON ST. • EL SEGUNDO, CAL. • OREGON 8-2665

Write in No. 130 on Reader Service Card

DIGITAL SUBTRACTOR has analog output



Model DS-12-A digital subtractor-converter automatically compares two input electronic signals that consist of digital pulses, subtracts them, and presents an analog signal output representing the difference between the two. Each of the two input channels will accept positive voltage pulses, O to 30 V. Repetition rates from O to 4095 pulses per block or data word are accommodated with 30 blocks per sec handled by the system, says **Computer Equipment Corp., Dept. S/A, 1931 Pontius Ave., Los Angeles 25, Calif.**

The analog output voltage is accurate to 12 bits of input information. The scale factor is 50 mv of output amplitude change for one bit difference between input channels. The unit accepts input pulse signals at bit rates ranging up to 250 Kcps and the inputs may be asynchronous.

Write in No. 228 on Reader Service Card

SWITCH takes 2000 ft-lb

This environment-proof switch is resistant to the effects of high shock and meets the requirements of MIL-S-901B (Navy) which call for a 2,000-foot-pound shock test without injury to the housing or the two enclosed single-pole double-throw switching units. It also meets the immersion test requirements of MIL-E-5272A Procedure 1. The switch 1EN75-R can be applied to missile and rocket launching platforms, gun mounts and other equipment requiring a sealed limit switch capable of withstanding impacts, Electric rating at sea level or 100,000 ft: 28 vdc, 24 apms., inrush; 4 amps., resistive and 115 vac., 5 amps., resistive, says **Micro Switch Div., Minneapolis-Honeywell Regulator Co., Dept. S/A, Freeport, Ill.**

Switching chamber is sealed and filled with an inert gas under pressure.

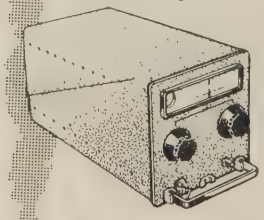
Write in No. 229 on Reader Service Card

more on page 190

A.W.A

ELECTRONICS

New concepts in electronics have been developed at AWA, as a result of experience with missile systems. Now they have a wider application. Here are some of the new AWA devices now available to industry.



U.H.F. WIDEBAND RECEIVER

Basic arrangement consists of R.F. amplifier, mixer, local oscillator, I.F. amplifier (A.G.C. controlled), cathode follower output stage. Tuning indicator (EM 34) is also fitted to receiver. The standard forms: one for airborne racking with special separate power supply unit, the other on larger chassis including power supply unit (conventional 19″ front panel). *Standard specification: 420-470 M/cs frequency range; 4 M/cs overall bandwidth, approximately 10 db noise factor; approximately 70 ohms input impedance, 200-250 V and 50-60 c/s input supply. Input is unbalanced, output is via low impedance (cathode follower) stage.*

DIRECTIONAL COUPLER

Of the 'Loop' type, suitable for measurements of RF power and Standing Wave Ratio in coaxial cables. Directional properties are largely unaffected by frequency changes, so coupler may be used to help obtain optimum termination of a 52 ohm coaxial system up to 600 M/cs. *Standard specification: Size 7″ x 4″ x 2½″; weighs 4 lbs. 3 ozs.; Power Measurement Range is Low range 1w.cw.max. High range 5w.cw.max.; less than 1% attenuation; better than 2% accuracy at frequency of calibration.*

All devices are adaptable to suit customers' own requirements. For further information consult:

COMMERCIAL ELECTRONICS DEPT.

SIR W. G. ARMSTRONG WHITWORTH AIRCRAFT LDT.
Baginton, Coventry, England
MEMBER OF THE HAWKER SIDDELEY GROUP

Write in No. 131 on Reader Service Card

WHY Oster® MEANS HIGH ACCURACY

For Missile Guidance Systems . . . Highly Accurate Precision Motor Tach Generators Utilizing Thermister Networks for Temperature Compensation.

- Calibrated to near 0° phase angles.
- Constant output from −55°C to +150°C.
- Manufactured from alloys with extremely low temperature coefficients.
- Mass produced under exceptionally rigid quality control.

One reason why Oster units have high accuracy:

BURTON BROWNE ADVERTISING

This Test Stand handles 12 units simultaneously, all temperature compensated to −55°C to +150°C. Also tests output voltage, phase shift and linearity. Test Stand has a speed accuracy of .01%, transformation accuracy of .001% and phase shift accuracy of 2 minutes.

For your exacting space age requirements, specify Oster motor tach generators.

New 16-page MOTOR TACH GENERATOR CATALOG No. 6000.
Lists 20 basic types for military, scientific and industrial applications.
Request your free copy today — on company letterhead, please.

OTHER PRODUCTS INCLUDE:

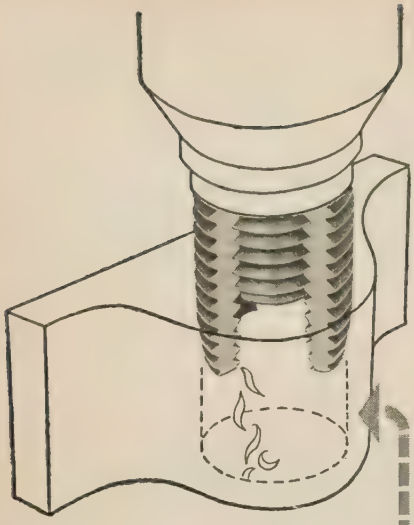
Servos	Computers
Synchros	Indicators
Resolvers	Servo Mechanisms
DC Motors	Servo Torque Units

John Oster **MANUFACTURING CO.**
Your Rotating Equipment Specialist
Avionic Division
Racine, Wisconsin

EASTERN OFFICE 610 Northern Blvd. • Great Neck, Long Island, New York • Phone: HUnter 7-4030 • TWX Great Neck N.Y. 2949
WESTERN OFFICE 6332 South Sepulveda Blvd. • Culver City, California • Phone: EXmont 1-5142 • TExas 2-1184 • TWX C. Mar. 7871

Engineers For Advanced Projects: Interesting, varied work on designing transistor circuits and servo mechanisms.
Contact Mr. Robert Burns, Personnel Manager, in confidence.

Write in No. 132 on Reader Service Card at start of Product Preview Section



TAP-LOK®

threaded insert...

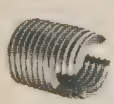
taps its own threads...

locks itself in...

in ONE OPERATION

With TAP-LOK inserts you get long thread life in wood, plastic, aluminum or other soft materials, as well as in harder materials where thread wear is a problem. TAP-LOKS cut their own threads and, because they force their way into the parent material, they lock themselves in permanently. Only one operation is needed, making TAP-LOK's initial cost the *only* cost . . . thus their *installed* cost is lower than that of any other threaded insert.

TAP-LOK inserts are available for *any* material, any application. For free samples and catalog, write today.



Slotted: — Full V-form external threads provide maximum locking torque; permit wide choice of mating hole sizes. Recommended for soft aluminum, zinc die castings, sand castings, plastics. Class 2B internal thread — MIL-MS 35914

H-Series: — A heavy walled insert with truncated root external thread and three-hole cutting edges for hard-to-tap higher-strength materials and to meet MIL and other specs calling for Class 3B thread fit for gaging after installation

W-Series:—Coarse-pitch external thread offers maximum strength; permits installation in small wooden sections without splitting. For furniture, cabinets and other wooden parts where stong, permanent threads are required

Another fastener development from —

TAP-LOK ***GROOV-PIN CORPORATION***

1121 Hendricks Causeway, Ridgefield, N. J.

Write in No. 133 on Reader Service Card

SERVO MOTORS in sizes 10 and 11

Servo motors in sizes 10 and 11 for 26, 55 or 115 volt ac 400 cycle operation, with special voltage requirements are available to order. The motors are 6 pole having a stall torque of .06 oz. in. minimum and a no load speed of 6500 rpm with rotor inertia Igm cm^2, says **Electro Products Div, Western Gear Corp., Dept. S/A, 132 W. Colorado St., Pasadena, Calif.**

The acceleration at stall is 42,000 radians/sec^2. They are designed to operate in ambient temperatures from —65° to +125° C. Length is $1\frac{11}{32}$".

Write in No. 230 on Reader Service Card

SHUTOFF VALVE for rocket propellant

This 6" rocket propellant shut-off valve for remote control has been developed for a major ICBM and can be controlled electrically or manually. Is designed for pneumatic or hydraulic actuation, says **Clary Dynamics, Dept. S/A, 408 Junipero St., San Gabriel, Calif.**

Operate at —35° to +160° F. with a response time of .5 to 1.5 seconds. With minor modifications, it is said, the valve will operate at temperatures of —320° to +250° F.

Write in No. 231 on Reader Service Card

LOW COST AUTOMATION controls machine tools

The Micro-Path control system uses a magnetic tape to record and play back complicated, continuous-path machine tool movements without the use of computer programing equipment, says **Micro-Path, Inc., Dept. S/A, 4949 W. 104th St., Inglewood, Calif.** Cost of the fully-automatic automation system is said to be about one-third that of the nearest competitive equipment.

The basic system can be applied to almost any existing machine tool and can also be used in many other control applications, such as transfer mechanisms, valve positioning, switch positioning, industrial drones, and telemetering controls.

Write in No. 232 on Reader Service Card

more on page 192

NEW MINIATURE PRESSURE TRANSDUCER BY COLVIN

- **Only One inch square — one inch long**
- **Withstands high vibration**
  35 G to 5000 CPS
  AVAILABLE IMMEDIATELY

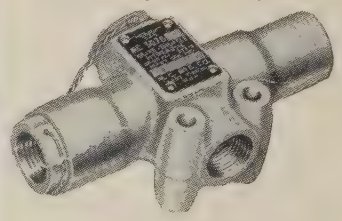
COLVIN LABORATORIES, INC.
364 Glenwood Avenue East Orange, N. J.

Write in No. 134 on Reader Service Card

MC *hydraulic*

SHUTTLE VALVE

Lightweight . . . compact . . . backed by solid experience



Designed for tomorrow's usage, at temperatures from —65°F to +275°F. Design and manufacture of precision hydraulic and pneumatic valves, fuel pumps and air compressors has been the specialized activity of M.C. Mfg. Co. for many years. Call on our backlog of solid experience for built-in reliability in components for your applications.

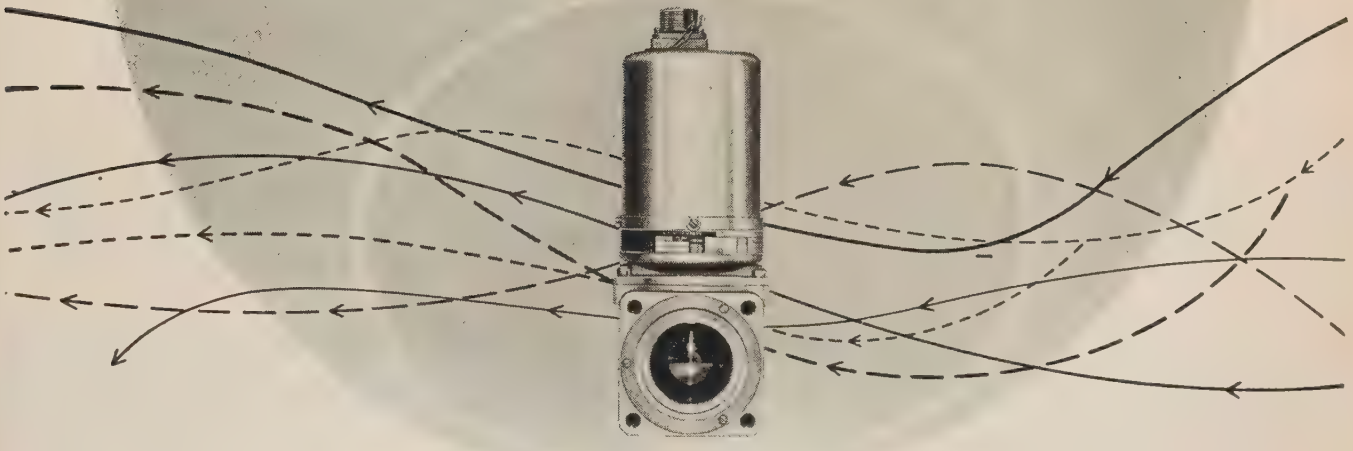
Specifications

FLUID: Hydraulic and air or nitrogen
PRESSURE: 3000 psi
TEMPERATURE: —65°F to +275°F
OUT PORT: Regular or Banjo
WEIGHT: .34 lb.

M. C. MFG. CO.
P.O. Box 126 • LAKE ORION, MICH.

Write in No. 135 on Reader Service Card

WHITTAKER SPHERICAL PLUG VALVES



RELIABILITY—PLUS UNLIMITED SCOPE FOR FLUID-FLOW CONTROL

These compact valves afford split-second control in high pressure and cryogenic flow systems. Whittaker's spherical plug construction provides the efficiency of "straight-through flow" with negligible pressure drop—almost constant low operating torque regardless of pressure ... *for unlimited advantages of flow control!* Available in a wide range of sizes, each valve is designed to customer specifications—may be actuated manually, pneumatically, hydraulically, or electrically. Since 1955, Whittaker Spherical Plug Valves have been produced in quantity for both missile and aircraft applications—let Whittaker engineers help *you* with your design problem. Write, wire, or phone.

Time-proven Reliability
In Hydraulic-Pneumatic-Fuel Controls

WC

WHITTAKER CONTROLS
DIVISION OF TELECOMPUTING CORPORATION

915 N. Citrus Ave., Los Angeles 38, Calif. • HO 4-0181

BRANCH OFFICES: New York, Dayton, Seattle, Wichita, Atlanta

Write in No. 136 on Reader Service Card at start of Product Preview Section

STATIC CONVERTERS are non-saturating

This S. I. C. Model 12-500 D series dc to dc converter is encapsulated and ruggedized for reliable operation under extreme environmental conditions, and is protected against overload and short circuit, says **Static Inverters Corp., Dept. S/A, 2501 E. 68th St., Long Beach, Calif.** Provides complete filtering of input and output voltages: dc output ripple is under 0.02%; dc input switching hash is less than 50 millivolts rms, it is said.

Operating temperature ranges from —40° C to + 70° C. Typical size 3⅝" x 4¼" x 5½" high. Weight is 6 lbs. Efficiency is placed up to 90%.

Write in No. 233 on Reader Service Card

DIODES have variable capacitance

The Varactor is a diffused silicon PN junction diode designed for variable capacitance with low loss at high frequencies. The unit complies with Mil-E-I Outline 7-1 for cartridge-type crystal rectifiers, says **Microwave Associates, Inc., Dept. S/A, Burlington, Mass.**

Minimum cutoff frequencies are graded in 10 kmc, starting from 20 kmc. Units are currently available as high as 60 kmc.

Write in No. 234 on Reader Service Card

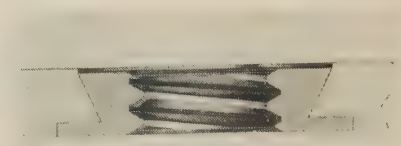
TELEMETRY COMPONENTS feature high stability

This line of airborne telemetry components features extreme stability under very high temperature and low power consumption. It is available in both standard and miniature size, says **Data-Control Systems, Inc., Dept. S/A, Danbury, Conn.**

The line includes voltage-controlled oscillators, which will drive most transmitters without a mixer amplifier, an all-solid state electronic commutator with an accuracy of better than 1 per cent, strain gage oscillators, mixers, and power supplies.

Write in No. 235 on Reader Service Card

FLUSH INSERTS for thin metal



This PEM self-clinching fastener provides a flush mounting area on both sides of the sheet to which applied. Previous products had flush area on reverse side of sheet only. The fasteners can be applied, one or several at a time, with pneumatic or oil-hydraulic squeezer or mechanical press. Metal displaced flows around back tapered shank securely locking fastener into sheet with high push-out resistance. Hex shape of embedded head provides high torque resistance as well, says **Penn Engineering & Mfg. Corp., Dept. S/A, Doylestown, Pa.**

Made in #303 stainles steel with thread sizes from #2-56 to #10-32, it is suitable for use in aluminum alloys, brass, copper, cold rolled steel and similar sheet materials in thicknesses from .061" up.

Write in No. 236 on Reader Service Card

more on page 194

FIBROUS SILICONE RUBBER

- *High permeability*
- *Excellent compression — deflection*
- *Outstanding compression set*
- *Good tensile and tear strength*
- *—65°F to 500°F temperature range*

COHRlastic FSR is a new and unique silicone rubber product. The unusual and random orientation of silicone fibers provides many useful properties superior to silicone sponge and foam. It should be extremely suitable for many applications including shock and vibration isolators, cushions, thermal insulators, high temperature press pads, pressure moldings, etc. COHRlastic FSR is being introduced in sheets 1/4" thick, 9" wide, 6' long, and in a density of 20 lbs./cu. ft. As applications develop, COHRlastic FSR will be made in continuous lengths, larger widths, different thicknesses and various densities in the range of 15-25 lbs./cu. ft.

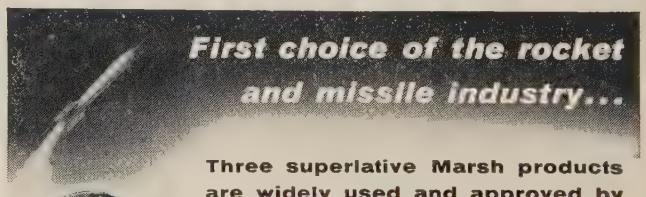
FREE SAMPLE and data — Write, phone, or use inquiry service

Leader in fabrication of silicone rubber products.

CHR CONNECTICUT HARD RUBBER

Main Office: New Haven 9, Connecticut

Write in No. 137 on Reader Service Card



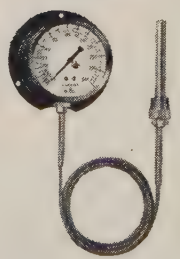
Three superlative Marsh products are widely used and approved by the aircraft and missile industry:

MARSH Pressure Gauges...

because they combine the most advanced features ever found in pressure, vacuum and compound gauges. There is a Marsh Gauge for every conceivable application.

MARSH Needle Throttling Valves...

because they are guaranteed to give micrometer regulation at HIGH pressures—pressure up to 10,000 psi—and any temperature up to 500° F.



MARSH Dial Thermometers...

because they offer the precision and accuracy a precision industry demands. Most complete line; wide temperature ranges, dial sizes, patterns, finishes.

All Marsh products available with AND threads

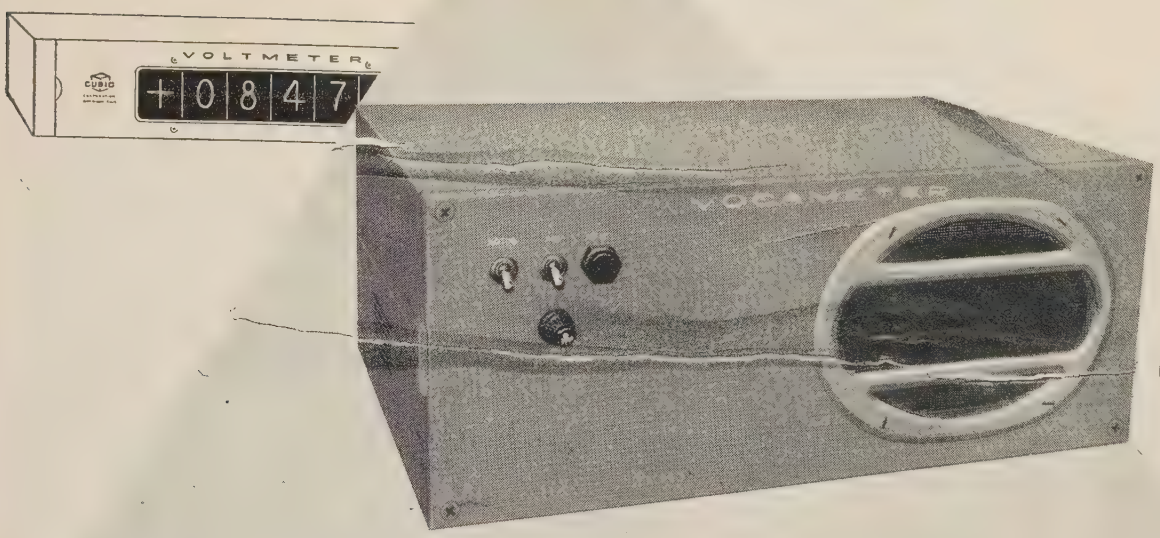
MARSH *New catalog covers all details*

MARSH INSTRUMENT CO. *Sales Affiliate of Jas. P. Marsh Corp.* **Dept. 43, Skokie, Ill.**

Marsh Instrument & Valve Co., (Canada) Ltd., 8407 103rd St., Edmonton, Alberta, Canada. Houston Branch Plant, 1121 Rothwell St., Sect. 15, Houston, Texas

Write in No. 138 on Reader Service Card

A **NEW** DIMENSION IN DIGITAL "READOUT" . . .



THE INSTRUMENT THAT READS ITSELF!

THE CUBIC TALKING METER

Now! Myriad applications for a Digital System with a new dimension in sensory impression . . . a "readout" in sight and sound.

Where high-intensity work factors require demanding attention of the eyes, where physical set-up factors prevent line-of-sight meter readings, where vocal impression creates previously unknown convenience . . . in any situation where sensory perception of a measurement needs to be intensified . . . the laboratory, the industrial facility, the classroom, an area of public traffic . . . Cubic Corporation's Vocameter provides a revolutionary new dimension to the fine science of electronic instrumentation.

In typical application, combined with the Cubic Digital Voltmeter and Control Unit, the Vocameter rapidly and accurately measures a voltage and reports in two dimensions . . . on an edge-lighted digital readout and in a clear voice.

The Vocameter Model AD-Series is adapted for direct connection to the plug channel at the rear of all Cubic Digital instruments to provide a vocal reading of the equipment's visual display. Exact wordage is at the option of the user, through 14 independent channels of voice storage, each channel capable of storing approximately half a second of wordage. "Readout" is through a panel-mounted loudspeaker and a speaker-muting earphone jack. Volume control and repeat-reading pushbutton are provided. Information can be recorded in a voice of your choosing, in any language or with any data desired for a unique application.

Write today for information on the Vocameter and other precision "building block" units in Cubic's "Digital Systems That Design Themselves."

CUBIC CORPORATION

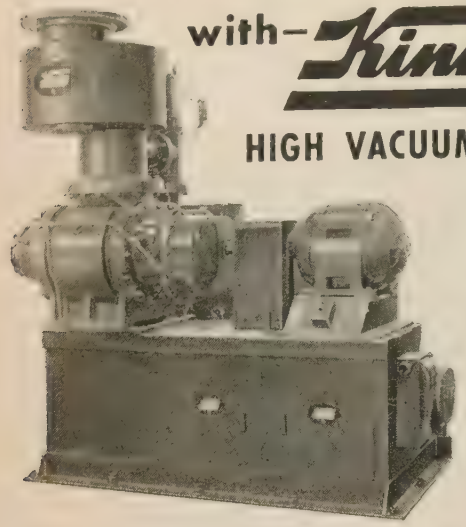
5575 Kearny Villa Road, San Diego 11, California

Electronic Engineering — With a Dimension for the Future

Write in No. 139 on Reader Service Card at start of Product Preview Section

Evacuate Your High Altitude and Environmental Chambers with—Kinney®

HIGH VACUUM PUMPS



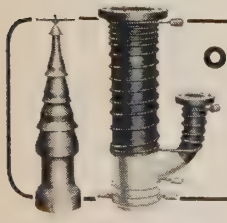
KMB 5000 Mechanical Booster Pump—5100 cfm

There are many very real advantages in using KINNEY High Vacuum Pumps and High Vacuum Equipment, among which are: the greater dependability of KINNEY Pumps...greater economy in operation and maintenance...greater pumping speed and the ability to hold low absolute pressures. And, in planning your High Altitude or Environmental Chamber the broad experience of KINNEY engineers can forestall pitfalls now and headaches in the future.

KINNEY pioneered the major advances in High Vacuum technology and today the KINNEY Line of High Vacuum Pumps is the broadest and *most comprehensive in the world!* From small laboratory size Compound Pumps with free air displacement of 2 cfm to two-stage Mechanical Booster Pumps rated at 5100 cfm, there are models to provide the pumping speeds and ultimate pressures you seek.

KC 2 Two-Stage Compound Pump—2 cfm

Get the new KINNEY catalog bulletins and latest information on KINNEY High Vacuum Pumps and Equipment—Write today!



OIL DIFFUSION PUMPS

For Vacuum in the order of 1 x 10-7 mm Hg, the KINNEY Line of High Speed and Fractionating Oil Diffusion Pumps features new design and performance advantages, plus a range of sizes from 1" to 32".

KINNEY MFG. DIVISION
THE NEW YORK AIR BRAKE COMPANY
3528G WASHINGTON STREET • BOSTON 30 • MASS

Please send me bulletins on KINNEY
☐ Mechanical Pumps ☐ Oil Diffusion Pumps

Name_____

Company_____

Address_____

City_____ Zone_____ State_____

Write in No. 140 on Reader Service Card

POSITION ENCODER has rugged shaft

Shaft position encoder for extreme ranges of environmental conditions, —65° to +162° F., provides up to 1024 positions per shaft rotation with high resolution and accuracy. The sealed unit, 4½" long, 3" diameter, weight 17 oz., has "O" ring seals on shaft and case conforms to MIL-Std for humidity, salt spray, vibration. Operates at +8g to 1,000 cps and under 100g steady state in longitudinal axis, says **Datex Corp., Dept. S/A, 1307 S. Myrtle Ave., Monrovia, Calif.**

This model C-701 uses brushes of precious metal alloys designed to maintain original accuracy resolution and phasing despite wear.

Write in No. 237 on Reader Service Card

MICA-FORMED TUBES stable above 1100° F

These tubes and coil forms remain physically stable and without loss of insulation value at 1100° F. temperatures and involve a technique which makes possible high production spiral winding of inorganic bonded muscovite mica paper. Tests of the "Pyrotherm" show that the tubes have 80 volts per mil electrical strength and 3.4 x 10^9 volume resistivity after 1000 hours. Their stability makes it unnecessary to compensate in mandrel size. They are exceptionally resistant to heat and cold shock and are unaffected by ordinary neutral lubricants or organic solvents. Arc resistance tests in excess of 300 seconds, says **Resinite Corp., Dept. S/A, 2035 W. Charleston St., Chicago 44, Ill.**

The tubes can be supplied in round, square or rectangular shape.

Write in No. 238 on Reader Service Card

SILICONE RUBBERS for continuous submersion

A new family of nitrile silicone rubbers, including NSR-X5602, is available in evaluation quantities. It is described as having "intermediate fluid resistance," and intended for intermittent contact with high-swell fluids or continuous immersion in milder fluids. It is a 60 durometer, relatively low modulus stock, suitable for airframe seals, boots, diaphragms and shock mounts. It can be fabricated by extrusion, molding or calendering, according to **General Electric Co., Dept. S/A, Waterford, N. Y.**

Other products to come for applications requiring outstanding high temperature oil resistance, it is said, will be NSR-X8701, a 70 durometer rubber.

Write in No. 239 on Reader Service Card

HEAT RESISTING ALLOY for jet aircraft

An air-hardening specialty steel, Dynaflex, possesses exceptionally high strength at elevated temperatures is said to be excellent material for structural components of jet aircraft and other allied applications where high strength and ductility are required. It has ability to resist softening upon continued exposure to temperatures up to 1000° F while providing high toughness and ductility at tensile strength levels up to 300,000 psi, according to **Latrobe Steel Co., Dept. S/A, Latrobe, Pa.**

Other important advantages are said to include exceptional ease in forming and working, good weldability, relatively low coefficient of thermal expansion, better than average corrosion and oxidation resistance, and low strategic alloy content. Available in billets, bars, and forgings and special shapes.

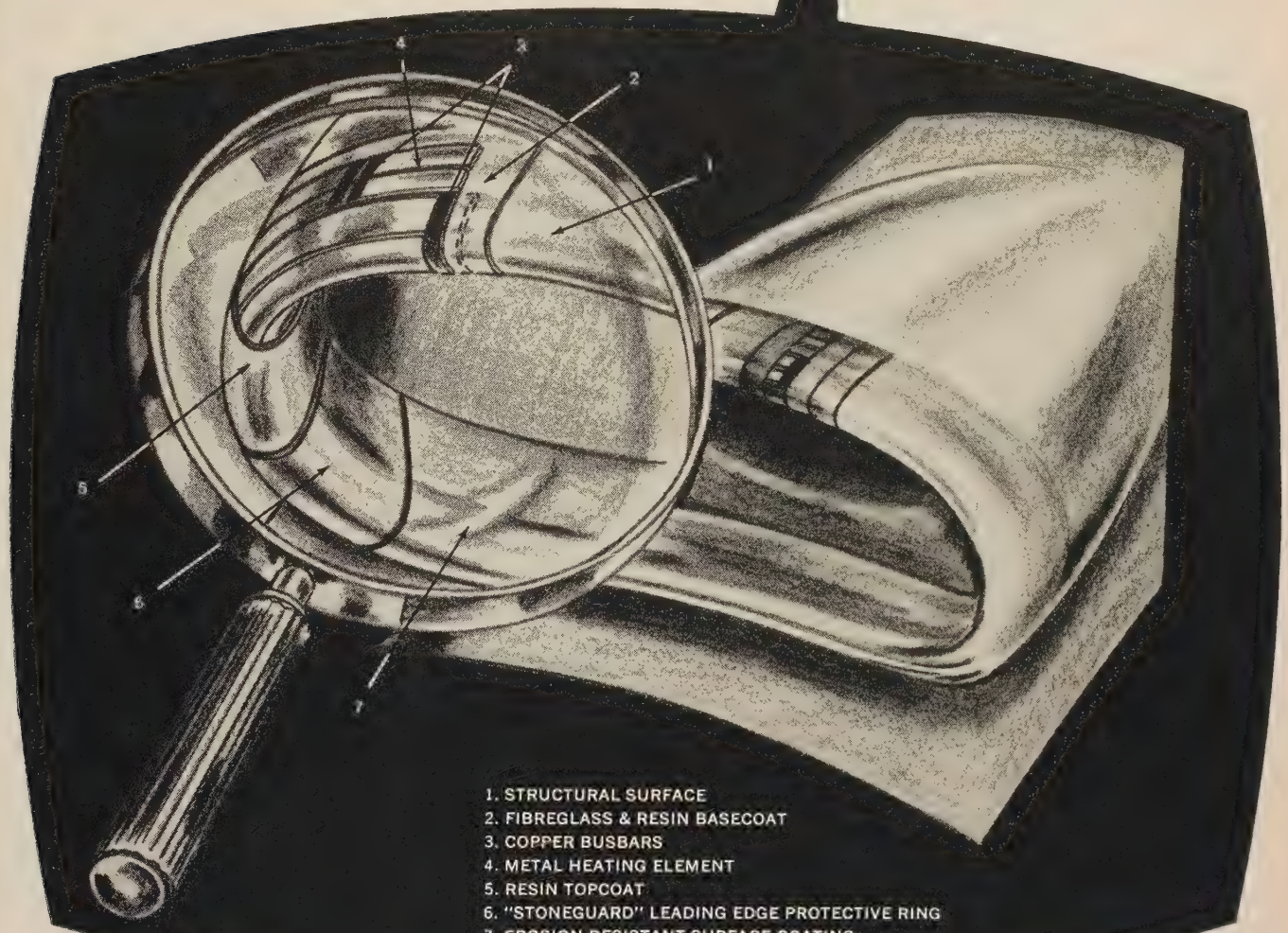
Write in No. 240 on Reader Service Card

more on page 196

SPRAYMAT

anti-icing/de-icing...

OVER
15,000,000 MILES
OF SERVICE


1. STRUCTURAL SURFACE
2. FIBREGLASS & RESIN BASECOAT
3. COPPER BUSBARS
4. METAL HEATING ELEMENT
5. RESIN TOPCOAT
6. "STONEGUARD" LEADING EDGE PROTECTIVE RING
7. EROSION RESISTANT SURFACE COATING

After 9 years of development, testing and service, **SPRAYMAT** electrothermal ice elimination system has been enthusiastically accepted in the United States, and is in use on such aircraft as Lockheed's Electra and North American's Sabreliner, and was successfully tested on Lockheed's C-130A. **SPRAYMAT** has long been in use on such aircraft as the Britannia, Comet, Caravelle, Friendship, Vanguard, Viscount 810 and many others.

SPRAYMAT can be applied to *any* surface, of any material, however complex the curvature. Simple field repairability and aerodynamic and thermal efficiency assures its superiority to any existing system.

Basically, as shown in the above diagram, **SPRAYMAT** consists of, first, a base of insulating resin; next a layer of metallic heater element of a controlled, predetermined design pattern; and finally a mirror-finish coating of insulating resin. Under normal operating conditions, the service life of **SPRAYMAT** will exceed that of the aircraft structure itself!

Other applications for **SPRAYMAT** include:
- solid rocket propellent fusing
- radiant heat panels
- heated tools and molds
- de-fogging of camera lenses
- heating of components in unheated unpressurized areas
- heat blankets

PacAero is **SPRAYMAT**'s sole United States manufacturer and distributor. A call or letter will bring you into immediate contact with a well-informed **SPRAYMAT** sales-engineer to discuss the application of **SPRAYMAT** to your specific ice-protection problems.

PACAERO ENGINEERING CORP.

PACAERO

3021 Airport Avenue, Santa Monica, California • TExas 0-2151 • EXmont 1-5281

A subsidiary of Pacific Airmotive Corporation, Burbank, California

Write in No. 178 on Reader Service Card at start of Product Preview Section

CHARACTERISTICS

	ANALYSIS	RECOMMENDED USE
1	Stainless Steel Ball and Race	For types operating under high temperature (800-1200 degrees F.).
2	Chrome Alloy Steel Ball and Race	For types operating under high radial ultimate loads (3000-893,000 lbs.).
3	Bronze Race and Chrome Steel Ball	For types operating under normal loads with minimum friction requirements.

Thousands in use. Backed by years of service life. Wide variety of Plain Types in bore sizes 3/16" to 6" Dia. Rod end types in similar size range with externally or internally threaded shanks. Our Engineers welcome an opportunity of studying individual requirements and prescribing a type or types which will serve under your demanding conditions. Southwest can design special types to fit individual specifications. As a result of thorough study of different operating conditions, various steel alloys have been used to meet specific needs. Write for Engineering Manual No. 551. Address Dept. S/A 59.

SOUTHWEST PRODUCTS CO.
1705 SO. MOUNTAIN AVE., MONROVIA, CALIFORNIA

Write in No. 141 on Reader Service Card

SURFACE COATING for high temperature

Having exceptionally high temperature properties which can be used continuously at 500° F and for short periods up to 600° F, Eccocoat C 26 is a clear epoxide surface coating. Surface resistivity is above 10^{15} ohms at room temperature and remains about 10^{14} at 500° F, says **Emerson & Cuming, Inc., Dept. S/A, 869 Washington St., Canton, Mass.** Moisture and chemical resistance is said to be outstanding.

Coating may be applied by dip, brush, or spray.

Write in No. 241 on Reader Service Card

FUEL PUMP meets Navy standard

This model 023104 fuel pump provides continuous delivery of the JP-4 or JP-5 fuel burned in the annular combustor of General Electric's T58 turboshaft engine. It is rated at 6.25 gpm at 4200 rpm and 850 psi, qualified to specification MIL-E-5009-A. It is dual element, having one gear-type positive displacement pumping element and one centrifugal-type which acts as a booster, says **Pesco Products, Dept. S/A, 24700 N. Miles Rd., Bedford, Ohio.**

Although the initial use of the T58 engine is to power helicopters, these pumps can be modified for fixed-wing aircraft.

Write in No. 242 on Reader Service Card

FUEL FLOW INDICATOR is integrally lighted

This EFU-1/A Mil-I-25860 is an integrally lighted remote station aviation fuel flow indicator. Type 9807-04 clearly displays to MIL L-25467A lighting aviation fuel flow as received from a MIL-T-8275 fuel flow transmitter. Dial is graduated in lbs./hr. x 1000 in a 330° arc with zero at dial's top and ending with 24 at 330°, according to **John Oster Mfg. Co., Dept. S/A, 1 Main St., Racine, Wis.**

Hermetically sealed round 2" case conforms to AND 10412 and electrical receptacles to AND 10066-14S-5P. Weight 7 oz. Government stock number is 6620-646-8035. Can be supplied with 28 volt lighting circuit.

Write in No. 243 on Reader Service Card

MODIFIER for epoxy resins

Improvements of 40% to 80% in the bonding strength of simple epoxy adhesives have been obtained with a new modifier trademarked Mod-Epox. Manufacturers can obtain bonding strengths equivalent to present-day adhesives at lower formulating costs or greater bonding strengths with use of the product in existing formulations, says **Monsanto Chemical Co., Dept. S/A, St. Louis 24, Mo.**

Steel-to-steel bonding strength of a simple epoxy resin and curing agent was improved more than 50% with the addition of 25 parts of Mod-Epox.

Write in No. 244 on Reader Service Card

SPRING RELAY for operating stability

A "molded module" contact spring construction for relays marks Models TT and TS. The "module" is a standard, single-pole, double-throw spring combination molded into a single compact assembly. Rigidly held in a matrix of tough plastic, the springs remain permanently in alignment, and in adjustment longer. Up to six modules can be incorporated into a relay, according to **Ohmite Mfg. Co., Dept. S/A, 3678 Howard St., Skokie, Ill.**

Sensitivity is said to be high for the size. Units will operate in high ambient temperatures up to 125° C.

Write in No. 245 on Reader Service Card

more on page 198

Missile and rocket components, impact extruded from Alcoa Aluminum. The largest impact shown above has 8-in. diameter, 36-in. length; Alcoa can make them as large as 12-in. diameter, 60-in length. The impacts shown use aluminum alloys 1100, 6061-T6, 2024-T4 and 7075-T6.

WHAT'S NEW IN ALCOA IMPACTS?

IN A FIELD as revolutionary, promising and relatively new as impact extrusion, you'd expect progress to be made *rapidly*. And it has! In the years since Alcoa pioneered this breakthrough in the metal-working arts, the impact process has been advanced and extended to cover a wide variety of shapes and forms and special applications . . . to cut costs in dozens of ways . . . and to produce, in the wink of an eye, complex components with tolerances down to 0.005 in.

EACH OF THE IMPACTS shown above is in production. Each represents at least one complexity that formerly would have posed a real production headache: each achieves the optimum properties of its particular alloy.

TOOLING COSTS? With few exceptions, the cost of impact tooling is substantially less than for other fabricating processes. This is especially true where the length of the part would require several steps by any other process—but with the impact process, even extremely long parts can be produced with just one set of tools and one operation, simply by varying the size of the original blank or slug.

IN GENERAL, it's an excellent idea to consider virtually *any* closed-end or tubular design as an Alcoa® Impact. For more specific information, and for on-the-spot assistance, the *best* procedure is to contact your nearby Alcoa sales office. Or, if you prefer, write to: Aluminum Company of America, 2027-G Alcoa Building, Pittsburgh 19, Pa.

Your Guide to the Best in Aluminum Value

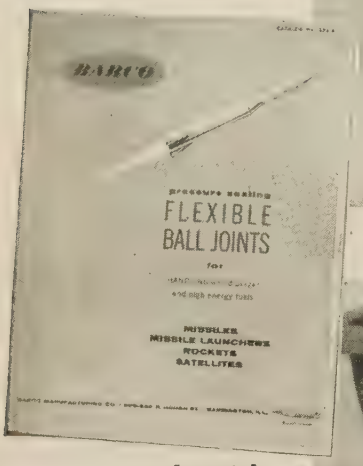
ALCOA ALUMINUM

For Exciting Drama Watch "Alcoa Theatre," Alternate Mondays, NBC-TV, and "Alcoa Presents," Every Tuesday, ABC-TV

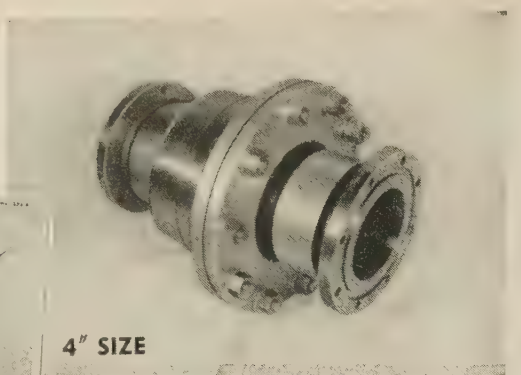
Write in No. 144 on Reader Service Card at start of Product Preview Section

BARCO FLEXIBLE JOINTS

For Handling High Energy Fuels . . . .

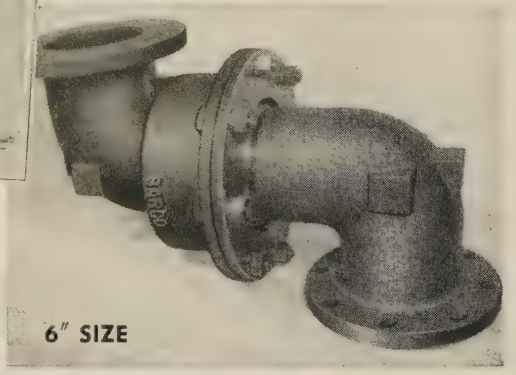


. . . . . liquid oxygen, white fuming and red fuming nitric acid, and JP 3, 4, and 5 fuel



4" SIZE

4" special stainless steel Barco Flexible Ball Joint for handling liquid oxygen.



6" SIZE

180° flanged 6" Barco Ball Joint for use in loading and unloading line handling liquid propellant.

-special designs for LOX and other Missile Fuels

Extensive design and manufacturing experience is yours to call upon at Barco for the handling of special liquid fuels in the aircraft, rocket, and missile industries:

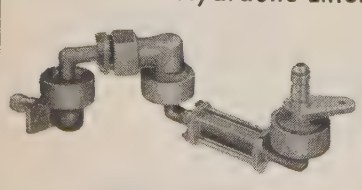
—Flexible Ball Joints for metal loading lines handling corrosive fluids.

—Special flexible joints with leakproof seals for conveying fluids at low temperatures down to −300°F. Also high temperature designs up to +1000°F.

—Special designs resistant to nuclear energy radiation.

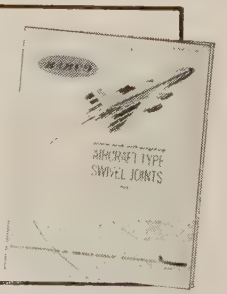
Barco joints provide flexibility *unlimited* for piping and tubing. Our engineers will be glad to work with you on special problems and assist with recommendations.

Flexible Hydraulic Lines for Missiles, Aircraft



MISSILE LAUNCHER HYDRAULIC ASSEMBLY

Barco produces high pressure self-aligning swivel joint and tubing assemblies for hydraulic pressures to 4,000 psi, and higher. Also a wide selection of standard and special swivel joints and assemblies for launching and flight gear. Sizes ¼" to 1".
ASK FOR NEW CATALOG 269-A.

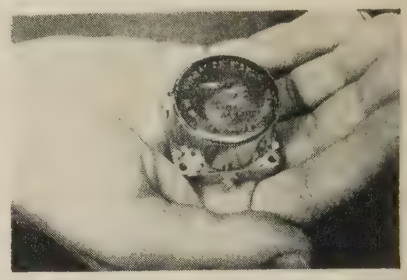


BARCO *Serving Industry Since 1908*
MANUFACTURING CO., 575H Hough St., Barrington, Ill.

AIRCRAFT DIVISION

Write in No. 143 on Reader Service Card at start of Product Preview Section

VIBRATION PICKUP has flat response curve



This miniaturized MB Type 11 Vibration Pickup is the "only eddy current damped unit with a flat response curve over its full operating range," and is said to be a "completely" new design. Under shock tests the pickup operated perfectly even after being subjected to impact up to 100g in all directions, says **MB Mfg. Co., Dept. S/A, 781 Whalley Ave., New Haven, Conn.**

The model is 1.42" square, 1" high and weighs 2.75 oz.

Write in No. 246 on Reader Service Card

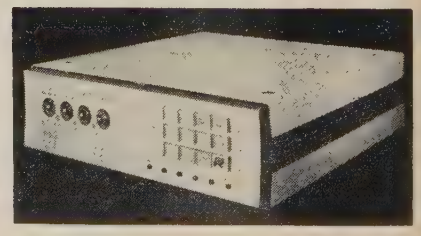
SOLENOID VALVE for airborne operation

This airborne solenoid shutoff valve, MC 2643, is normally closed and of the direct acting type, intended for use in air or nitrogen systems. Ambient temperature range is −65° F to +160° F, says **M. C. Mfg. Co., Dept. S/A, Lake Orion, Mich.** Operating pressure is 200 psi.

Internal leakage with 200 psi at the inlet port is 4 cc per hour maximum. Actuation time, either opened or closed, is 50 milli-seconds maximum. Port connections for ¼ O. D. tubing. Weight, .95 lb.

Write in No. 247 on Reader Service Card

ANALOG-DIGITAL CONVERTER has 24-kc word rate



The flexible Radicon converts analog information to digital and digital to analog for use in modular data systems. It provides visual display and six selectable output codes compatible with most commercial digital computers, says **Radiation, Inc., Dept. S/A, P.O. Box 37, Melbourne, Fla.**

Asynchronous operation at up to 24 kc word rate, accuracy to ±0.025% full scale, and miniaturized solid-state construction are featured.

Write in No. 248 on Reader Service Card

more on page 202

Experience—*the extra alloy in* **Allegheny Stainless**

ANTI-ICING DUCTS, made from Allegheny Ludlum AM350, are designed to withstand temperatures to 700F and pressures to 200 psi. Wall thicknesses .025 in. to .187 in.; outside diameters, 1½ to 4½ in.

made from Allegheny Ludlum precipitation-hardening stainless:

Prop-jet's anti-icing ducts take high heat and pressure in stride

The anti-icing system of a new prop-jet airliner was designed to operate under high heat and pressure, yet the ducting had to be as light as possible. AM350 was specified. Both AM350 and AM355, Allegheny Ludlum's precipitation-hardening stainless steels, have strength/weight ratios at 600F five times greater than the usual aluminum aircraft alloy. In fact, AM350 and AM355 maintain high strength from room temperature up to 1000F.

These space age metals have other properties highly desirable: excellent corrosion resistance, ease of fabrication, low temperature heat treatment, good resistance to stress corrosion.

These features have been used to advantage in airframe structural members, airframe skins, pressure tanks, power plant components, high pressure ducting, nacelles and other missile and supersonic aircraft applications.

availability: AM350, introduced several years ago, is available commercially in sheet, strip, foil, small bars and wire. AM355, best suited for heavier sections, is available commercially in forgings, forging billets, plates, bars and wire.

corrosion resistance: Compared to the more familiar stainless grades, AM350 and AM355 resist corrosion and oxidation better than the hardenable grades (chromium martensitic) and only slightly less than the 18 and 8's. They resist stress corrosion at much higher strength levels than do martensitic stainless grades.

simple heat treatment: High strength is developed by two methods. Both minimize oxidation and distortion problems. The usual is the Allegheny Ludlum-developed sub-zero cooling and tempering (SCT): minus 100F for 3 hrs plus 3 hrs at 850F. Alternate method is Double Aged (DA): 2 hrs at 1375F plus 2 hrs at 850F.

easy fabrication: AM350 and AM355 can be spun, drawn, formed, machined and welded using normal stainless procedures. In the hardened conditions, some forming may be done . . . 180 degree bend over a 3T radius pin. Also AM350 can be dimpled in the SCT condition to insure accurate fit-up.

For further information, see your A-L sales engineer or write for the booklet "Engineering Properties, AM350 and AM355." *Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.* Address Dept. AV-19.

W&W 7241

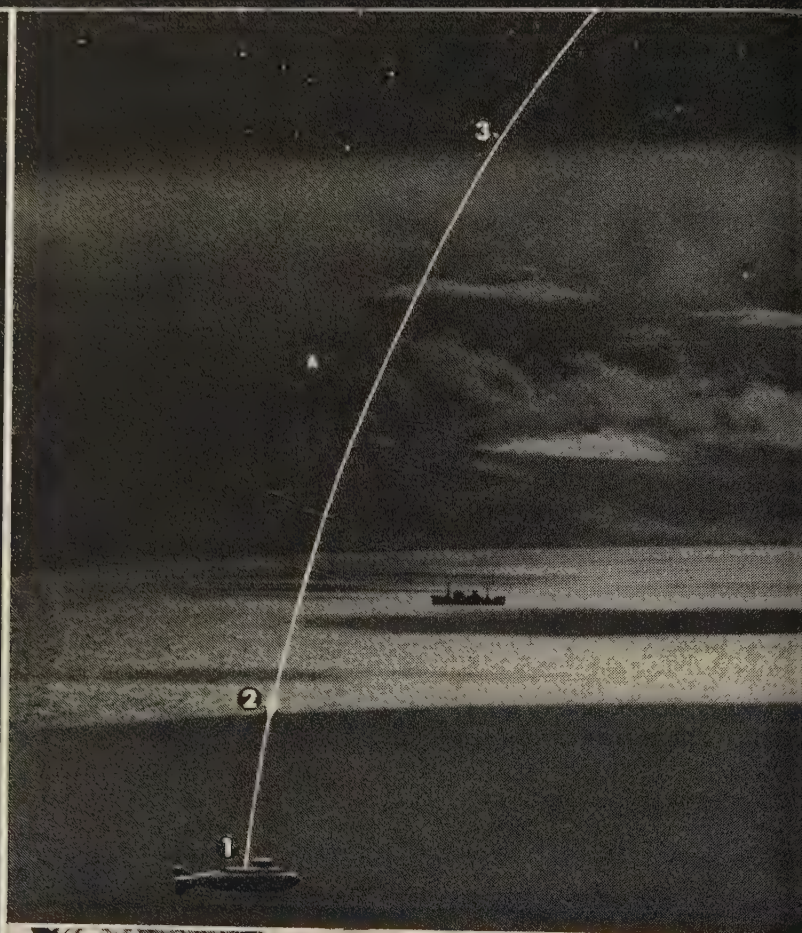
ALLEGHENY LUDLUM

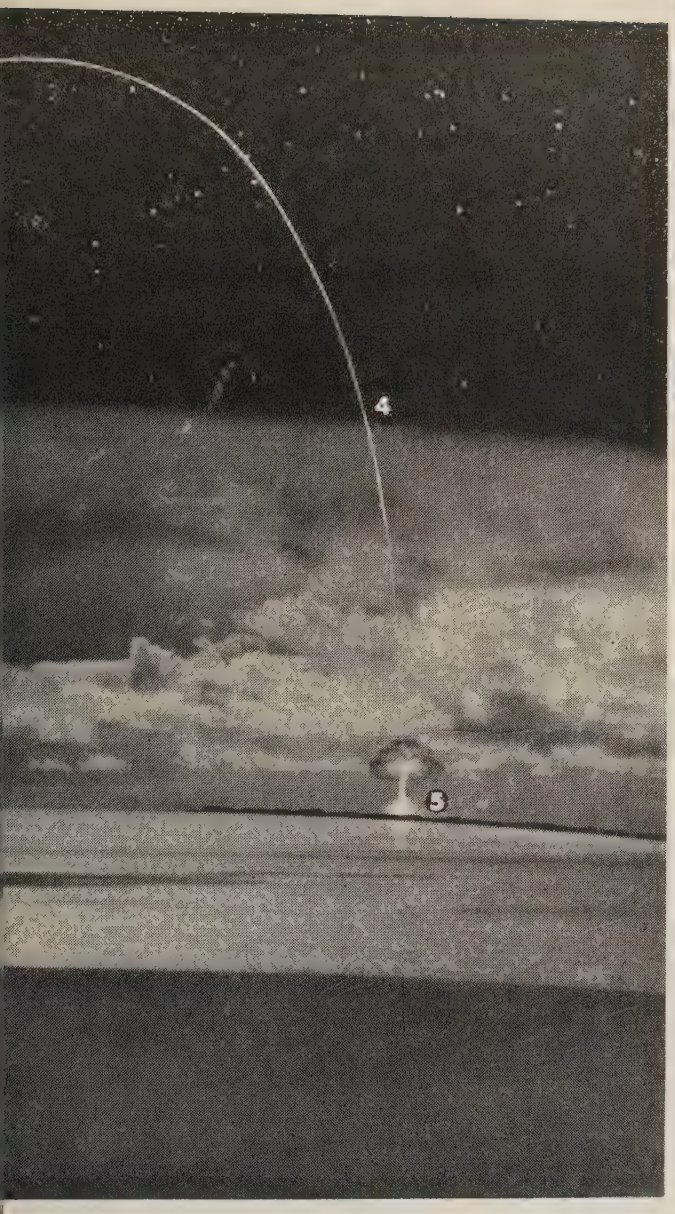
EVERY FORM OF STAINLESS . . . EVERY HELP IN USING IT

Write in No. 142 on Reader Service Card at start of Product Preview Section

The Lockheed-developed U.S. Navy POLARIS:

Missiles launched from ocean depths





Left: *"Operation Sky-Catch" tests,* conducted jointly by U. S. Navy, Westinghouse and Lockheed, reveal effects of launch stresses. To prevent damage to POLARIS test missile components, huge overhead assembly catches it in mid-air.

Far left: *Carrying awesome destructive power,* Navy's POLARIS is markedly smaller than other U. S. ballistic missiles of same range. To enable one submarine to carry many missiles, Lockheed scientists achieved miniaturization breakthroughs on all major systems of POLARIS.

Above: *Propulsion system firings* light up night sky at Lockheed Missiles and Space Division's 4000-acre test base in the Santa Cruz mountains, Calif. A nearby vertical test stand permits simulated flights of complete POLARIS missiles, to test their propulsion and guidance systems.

Left: *Nuclear powered U. S. Navy sub* (1) launches solid-propellant POLARIS missile which erupts from ocean depths (2)—then rockets its way on a ballistic missile trajectory high above the earth's atmosphere (3) into outer space. Re-entering the atmosphere (4) the re-entry body of the POLARIS plunges earthward to destroy its target (5).

Launching an IRBM from submerged submarines involves technological developments that are unique in ballistic missile history.

As POLARIS Missile System manager and prime contractor, Lockheed's Missiles and Space Division is responsible for coordinating all phases of its design, development, and production.

The POLARIS, a solid-propellant missile, will be operational in 1960—ahead of schedule. The operational missiles will be delivered to U. S. Navy submarines in Lockheed ready-service transporters under controlled humidity and temperature conditions. And Lockheed's ACRE—Automatic Checkout and Readiness Equipment—will maintain the constant ready-to-fire capability of POLARIS missiles, right up to the moment of launch.

With an ultimate range of 1500 nautical miles, the POLARIS will become one of the most formidable deterrent weapons ever devised. For any significant military target on earth will be within range of its nuclear warheads.

LOCKHEED

JET TRANSPORTS • JET FIGHTERS • JET TRAINERS • COMMERCIAL & MILITARY PROP-JET TRANSPORTS • ROCKETRY
BALLISTIC MISSILE RESEARCH & DEVELOPMENT • WEAPON SYSTEM MANAGEMENT • ANTI-SUBMARINE PATROL AIRCRAFT
NUCLEAR-POWERED FLIGHT • ADVANCED ELECTRONICS • AIRBORNE EARLY-WARNING AIRCRAFT • AIRPORT MANAGEMENT
NUCLEAR REACTOR DESIGN & DEVELOPMENT • GROUND SUPPORT EQUIPMENT • WORLD-WIDE AIRCRAFT MAINTENANCE

TRAINING EQUIPMENT DESIGN

The Los Angeles Division of North American Aviation—Weapon System Contractor for the nation's two most advanced manned weapon systems, the B-70 and F-108—has top-level positions available for

Training Simulator Designers

These highly-qualified engineers will coordinate and monitor the over-all design of training simulator equipment for the most advanced weapon systems projects.

Background preferred: Graduate Electrical Engineer with minimum of four years' experience in design of analog and digital computers with application to simulation requirements.

For more information please write to: Mr. P.G. Stevenson, Engineering Personnel, North American Aviation, Inc., Los Angeles 45, California.

THE LOS ANGELES DIVISION OF
NORTH AMERICAN AVIATION, INC.

SOLVENT *has dual function*

The metal degreasing grade of Nialk trichlorethylene can be used for both the flushing of rocket and missile parts and vapor degreasing, says **Hooker Chemical Corp., Dept. S/A, Box 344, Niagara Falls, N.Y.** The new grade thus contributes to simplified purchasing, inventory and materials handling.

The solvent is sufficiently stable to make possible repeated recovery and reuse. It has a residue on evaporation of 0.0005 per cent maximum and meets all impact sensitivity requirements.

Write in No. 208 on Reader Service Card

CONNECTOR *for 1200 deg F temperatures*

Electrical integrity and hermetic sealing can be maintained by this electrical connector in temperatures up to 1200 deg F, says **Technical Industries Corp., Dept. S/A, 389 N. Fair Oaks Ave., Pasadena, Calif.** The connector is made of 300 Series stainless steel with a chemical bond to a new ceramic, free from boron, and it can operate in nuclear environments without deterioration.

The device is impervious to shocks of over 700 deg F. A new keyway design serves to prevent keyway detachment from connector barrels and to achieve greater attaching force to connector and receptacle. The connector is available in most popular configurations, including the subminiature sizes.

Write in No. 209 on Reader Service Card

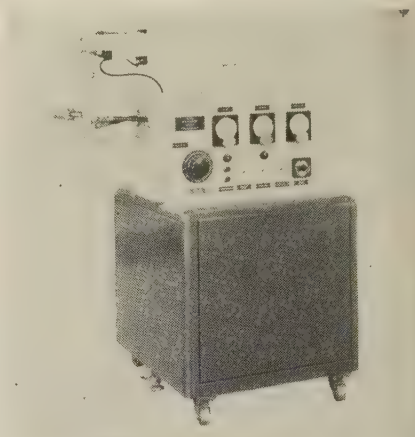
POWER PACKAGE *for many components*

A large number of components in a space vehicle control system can be integrated by this new pneumatic power package, says **Randall Engineering Corp., Dept. S/A, 5933 Bowcraft St., Los Angeles 16, Calif.**

Among these components are a high pressure GN^2 storage tank, filter, filler valve, high pressure regulator, two-position, solenoid-controlled shutoff valve, and high and low pressure transducers.

Write in No. 210 on Reader Service Card

FOAMING MACHINES *meter automatically*



Automatic metering and mixing of rigid, semi-rigid and flexible Stafoam polyurethane are possible with the Stafoamer series of portable foaming machines. The machines now bring mass production of polyurethane plastic parts and structures within range of smaller firms, according to **American Latex Products Corp., Dept. S/A, 3341 W. El Segundo Blvd., Hawthorne, Calif.**

All five types in the series are 70x38x32 in. and have ratio limits of 11.07:1 to 2:1. The compressed air requirement is 80 to 100 psig. Resin and catalyst flow is varied by gear changes, except in the Model SM, which uses variable drive for catalyst flow.

Write in No. 211 on Reader Service Card

CAMERA *comes with display*

A 70mm camera for recording high-speed transient instrumentation phenomena and a companion five-channel display unit have been developed by **Sir W. G. Armstrong Whitworth Aircraft, Ltd., Dept. S/A, Baginton, Coventry, England.** Magazine capacity of the camera is 500 to 800 ft, and the device has four normal operating speeds, including 18 and 150 ips.

The display unit is part of a wide-range instrumentation system using a cathode-ray tube display. An optical system is used to superimpose the traces for continuous film photography. Also suited to telemetry uses are a high-speed sampling switch with 24 or 48 segments, and a transistorized galvanometer amplifier. The switch, which can withstand missile environments, operates at speeds up to 200 rps. The amplifier can drive recording galvanometers with a resistance of 50 ohms and a working range of dc to two kc.

Write in No. 212 on Reader Service Card

more on page 204

Reliability is the prime factor in both aircraft and submarine bearings. The engineer must know *in advance* just how much each bearing can take in terms of speed, repeated shock loadings, millions of revolutions.

Over the years, Rollway has fulfilled military requirements for bearings in a wide range of applications . . . experience that is reflected in the new *Air-Rol* Data Book, which contains new and vital criteria for bearing selection. Engineers may obtain it by writing on company stationery to Rollway Bearing Company, Inc., Syracuse, N. Y.

ROLLWAY®

Air-Rol® BEARINGS

COMPLETE LINE OF RADIAL AND THRUST CYLINDRICAL ROLLER BEARINGS

ENGINEERING OFFICES: Syracuse • Boston • Chicago • Detroit • Toronto • Pittsburgh • Cleveland • Seattle • Houston • Philadelphia • Los Angeles • San Francisco

Write in No. 152 on Reader Service Card at start of Product Preview Section

Here is a man you should know, he's a

DELAVAN FUEL INJECTOR SPECIALIST

James R. Brucker specializes in injection devices using flow controls. He's a Senior Project Engineer with Delavan. And during his six years of developmental experience, his products have become bill-of-material items on some of the world's most advanced jet engines for aircraft and missiles.

It's specialized engineering talent like Jim Brucker's that has made Delavan first choice for fuel injection problem solving. If fluid metering and atomization are part of your product, take advantage of Delavan's specialized experience and proven ability to deliver aircraft quality. Send specifications to the address below for obligation-free recommendations.

DELAVAN *Manufacturing Company*

West Des Moines, Iowa

World's largest nozzle specialist

Write in No. 145 on Reader Service Card

LINEAR BALL BUSHINGS for military systems

These Ball Bushings, designated INST-258 and INST-396, are for use on shaft diameters of 0.1246″ and 0.1871″. Overall dimensions are: O.D.—0.3125%, Length—0.5″ and 0.375″ and 0.562″ respectively. They weigh 0.15 and 0.30 ozs. Each bearing contains three complete ball circuits with each circuit containing 16 balls in the smaller and 17 in the larger. Fabrication of precision ball circuits was made possible by milling techniques, using a 16 to 1 pantograph ratio, according to **Thomson Industries, Inc., Dept. S/A, Manhasset, N. Y.**

These bushings are said to be extremely rugged, capable of withstanding high vibrational and shock loads.

Write in No. 249 on Reader Service Card

SOLENOID VALVE is corrosion-proof

This 3-way solenoid valve, with full 1/16 orifice (0-500 psi) to 3/16 orifice (0-70 psi) holds no restrictions on orifice sizes and is corrosion proof, only one internal moving part and a completely protected solenoid coil. Internal media does not pass around solenoid plunger. Coil is sealed from air, oil, gas and water and will not overheat on continuous duty. Coils for continuous or intermittent duty, ac or dc, are interchangeable, says **Airmatic Valve, Inc., Dept. S/A, 7317 Associate Ave., Cleveland 9, Ohio.**

Life expectancy is very high and can be extended greatly by inserting a 1-piece valve plunger without disturbing rigid piping.

Write in No. 250 on Reader Service Card

ULTRASONIC CLEANERS in combinations

Complete ultrasonic cleaning systems in matched counter-height cabinets enable many combinations for individual users. Welded of 16-gage 316 L stainless steel to uniform dimensions (26x24x32 in.), the installation may be three basic units: generator, tank, filter, with additions of rinse tank and dryers if desired, says **Branson Ultrasonic Corp., Dept. S/A, 40 Brown House Road, Stamford, Conn.**

R-F output of generator at 40 kc is 500 w average, 2000 w peak on pulses. Power input is 1.5 kw, 151 volts ac (50-60 cycles), or 220 volts single-phase ac. Generator has forced air-cooled, circuit breaker with indicating light, low voltage control for maximum stability.

Write in No. 251 on Reader Service Card

RELAY has 5-amp contact

This CVE type 4C relay is a small, hermetically sealed 4PDT dc relay featuring a contact rating of 5 amperes at 30 volt dc, and has a heavy contact structure to make and break larger currents. Specifications call for unit operation at ambient temperatures up to 125° C; vibration specified to 2000 cps at 20G acceleration. It shows no physical damage or change in electrical characteristics at a minimum of 200G's mechanical shock, while a 75G minimum electrical shock of 11 milliseconds duration produces no contact opening energized or de-energized, says **Couch Ordinance, Inc., Dept. S/A, 3 Arlington St., North Quincy, Mass.**

Electrical specifications include insulation resistance of 1000 megohms minimum; dielectric strength of 1000 volts rms, 60 cycles; resistance of 0.020 ohms maximum (100 mv @ 5 amp dc), and a rating of 5 amp @ 30 vdc, resistive load.

Write in No. 252 on Reader Service Card

more on page 206

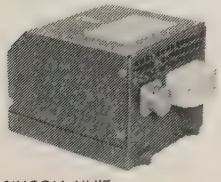
Boeing 707 and Convair 880 rely on Chatham power conversion units

THE Boeing 707 and Convair 880 represent the very latest developments in luxurious air travel. Standard equipment on both includes power conversion units made by Chatham—world's number one maker of power supplies for missiles and military and commercial aircraft.

Chatham airborne conversion equipment features minimum size and weight. Because Chatham makes its own solid-state components—silicon, germanium, selenium—our designers are not limited by available stock and can tailor components to fit power supply design, shaving excess inches and ounces.

Reliability is unsurpassed. Chatham power supplies show a uniformly high performance record in aircraft of all types and each unit reflects a long-standing reputation for trustworthy electronic equipment.

Chatham has many power supplies in stock, ready to go . . . or will design and produce a unit to your specifications. Either way, you can fill any power conversion need—AC to DC, DC to DC, DC to AC—with an efficient, high reliability unit made by Chatham. Contact: Chatham Electronics, Division of Tung-Sol Electric Inc., Livingston, New Jersey.



SILICON UNIT
Model 28VS50

SELENIUM UNIT
Model 28V50C

CHATHAM ELECTRONICS
division of
TUNG-SOL ELECTRIC INC.

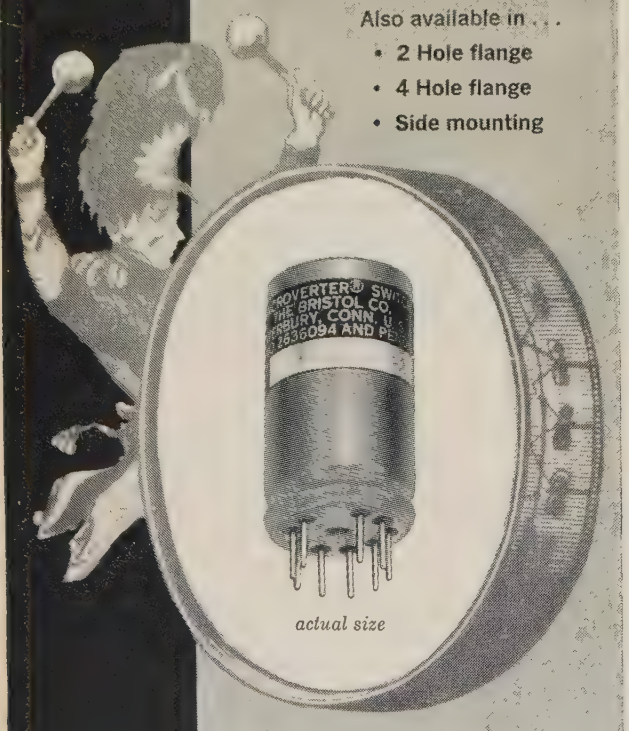
CHATHAM *... world's leading supplier of airborne conversion equipment.*

Write in No. 146 on Reader Service Card at start of Product Preview Section

BRISTOL
miniature
DPDT
chopper
C1430 Series

- Excellent tracking
- Miniature size
- Phase stability with temperature
- High vibration rating
- High contact rating
- Long life • Reliability
- Versatility

Also available in . . .
- 2 Hole flange
- 4 Hole flange
- Side mounting



actual size

For complete specifications, write:
Aircraft Components Division,
The Bristol Co.,
150 Bristol Road,
Waterbury 20, Conn. 9.19

BRISTOL FINE PRECISION INSTRUMENTS FOR SEVENTY YEARS
Write in No. 147 on Reader Service Card

SAFETY RELIEF VALVE for helium

This all stainless steel safety relief valve is for helium, gas, liquid oxygen, and hydraulic applications. In gaseous, hydraulic, and liquid oxygen service this Aero valve reseats within 3 to 9% of set pressure in ranges from 5 to 15,000 psi. The valve operates successfully in LOX systems at temperatures below −300°. In high pressure helium service it is certified to hold helium "bubble tight" to within 3½% of set pressure, according to **Specialty Engineering Co. Dept. S/A, 264 W. Fairview, San Gabriel, Calif.**

It is made in various line sizes to customer needs.

Write in No. 253 on Reader Service Card

SWITCHES are gold-laminated

Using gold-laminated contacts and slip rings for extremely corrosive atmospheres, in recent tests this Daven type 11-CM-32, single-pole, 32-position, shorting type switch was suspended in a sulphur atmosphere at 45° C for 245 hours. The initial contact resistance reading before suspension was .001 ohm to .002 ohm; after, it was .0021 to .0025 ohm, says **The Daven Co., Dept. S/A, Livingston, N. J.**

The gold-laminated contacts and slip rings are available for use where extreme reliability is demanded of a switch in a highly corrosive atmosphere.

Write in No. 254 on Reader Service Card

VENT VALVE for fuel tanks

This vent relief valve is meant to release pressure on fuel tanks while being fueled, maintain pressure for distribution of fuel load while in flight, and admit air if pressure becomes negative in flight. Engine bleed air actuates the normally closed valve. The molded valve seat and guide offers universal adaptability and light weight. The 31-1876-000 unit employs a ceramic piston and cylinder with good tolerance for temperature extremes, a low friction coefficient, resistance to corrosion, and to contaminated fuel, says **Aero Supply Mfg. Co., Inc., Corry, Pa.**

The 1″ line size weighs 1.3 lb. Fuel temperature range is from −65° F. to +135° F; ambient range is from −65° F. to +165° It is qualified in accordance with Mil-F-8615.

Write in No. 255 on Reader Service Card

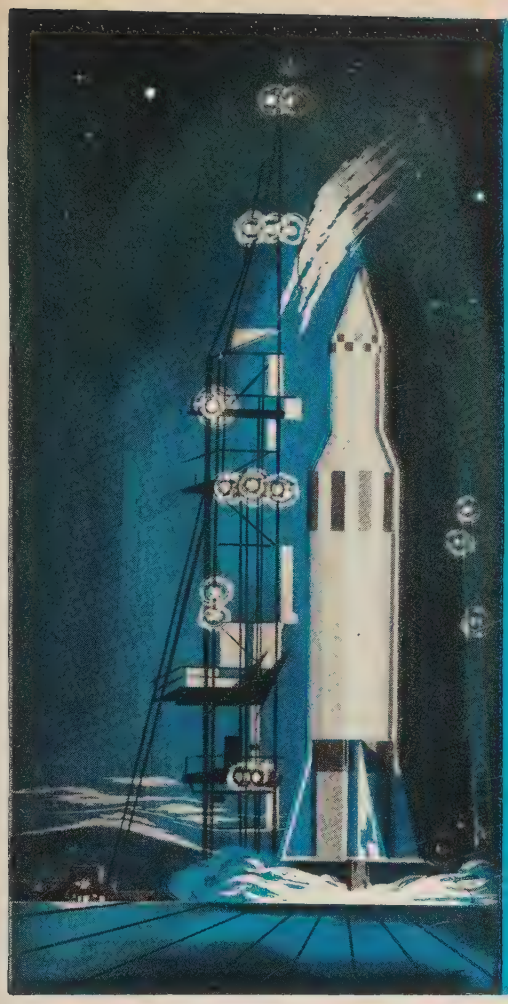
GAS GENERATOR adapts to many missiles

A gas generator that uses the monopropellant iso-propyl nitrate (IPN) provides a compact and versatile source of high pressure gas for operating the internal power supply machinery of guided missiles, says **Sir W. G. Armstrong Whitworth Aircraft Ltd., Dept. S/A, Baginton, Coventry, England.** Generator design contributes to maximum economies of space and weight, and the unit is adaptable to almost every type of guided weapon.

The Type TP-1 generator has a maintenance-free storage life of two years when it contains collant, IPN, and the auxiliary charge. The unit delivers gas at a temperature of 400 deg C and a pressure of 625 lbs/sq in. Fuel and coolant are contained in a light-alloy cylinder, and they are expelled from it by means of a pressurized coupled piston assembly.

Write in No. 256 on Reader Service Card

more on page 214

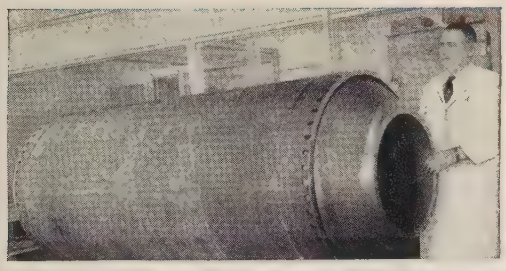


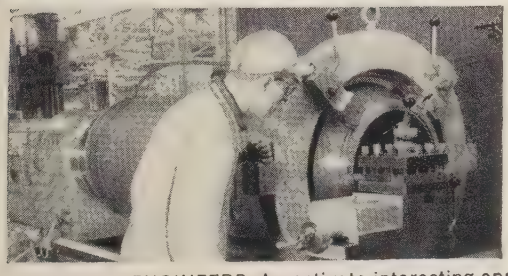
leading in

THRUST

HARDWARE

BOOSTERS • SUSTAINERS • ENGINE CASES • NOZZLES





QUALIFIED ENGINEERS: Investigate interesting opportunities at Ingersoll Kalamazoo Division.

The Ingersoll Kalamazoo Division has been producing missile metal parts since 1951 when the first Snark booster cases were made. Today, nearly half the Nike Hercules boosters and sustainers have been made with Ingersoll Kalamazoo Division production skills.

RESEARCH AND DEVELOPMENT and prototype fabrication are going on at the Ingersoll Kalamazoo Division utilizing such new methods as hydrospinning and concussion, or explosive, forming, which provide today's solutions to problems in metal parts production.

FABRICATION AND ASSEMBLY on a PRODUCTION line basis of large missile parts is routine at the Ingersoll Kalamazoo Division involving such processes as annealing, machining, hydrospinning, welding, rolling, etc.

A capable staff of engineers is available at the Ingersoll Kalamazoo Division who are experienced in the DESIGN, FABRICATION AND ASSEMBLY of major missile hardware parts. These engineers are ready to tackle your problems.

Borg-Warner Corporation

ENGINEERING B-W PRODUCTION

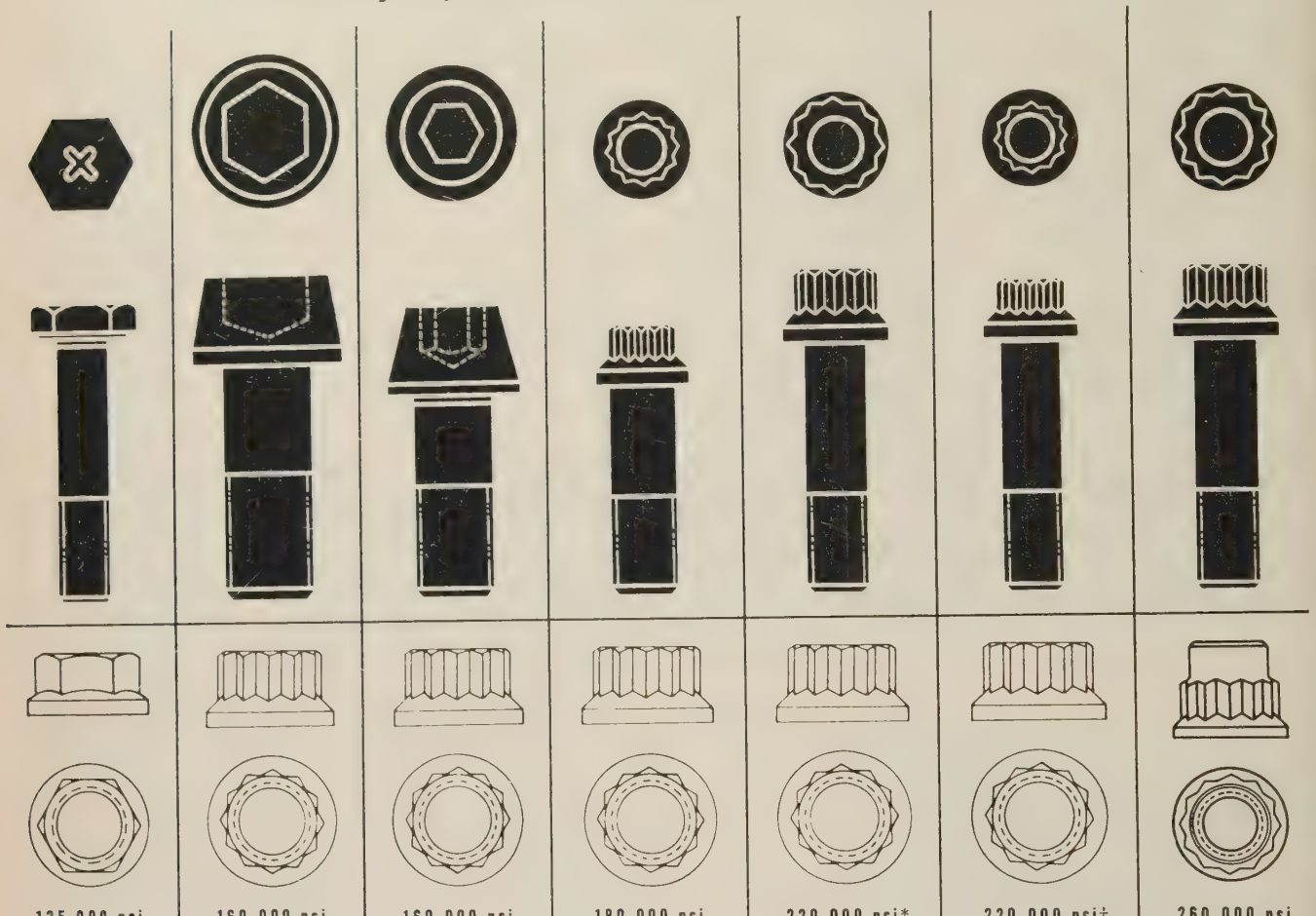
INGERSOLL KALAMAZOO DIVISION

KALAMAZOO, MICHIGAN

Write in No. 148 on Reader Service Card at start of Product Preview Section

Just name the tensile strength . . .

SPS offers a tension bolt and companion locknut for every application up to 260,000 psi



125,000 psi	160,000 psi	160,000 psi	180,000 psi	220,000 psi*	220,000 psi†	260,000 psi
AN 3 hex head external wrenching bolt and SPS FN-12 Featherweight hex locknut. Sizes #4 through 1 in.	NAS 144 internal wrenching bolt and SPS FN-18 Featherweight 12-point external wrenching locknut. Sizes ¼ through 1½ in.	(high fatigue strength) MS 20004 internal wrenching bolt and SPS FN-18 Featherweight 12-point external wrenching locknut. Sizes ¼ through 1½ in.	NAS 624 12-point external wrenching bolt and SPS FN-18 Featherweight 12-point external wrenching locknut. Sizes ¼ through 1½ in.	SPS Hi Psi EWB-22 12-point external wrenching bolt and SPS FN-22 Featherweight 12-point external wrenching locknut. Sizes #10 through 1½ in.	SPS Hi Psi LWB-22 12-point external wrenching bolt provides 220,000 psi muscles in a 180,000 body. Weight savings up to 32% when used with SPS FN-22. Sizes #10 through 1½ in.	SPS Hi Psi EWB-26 12-point external wrenching bolt and SPS FN-26 Featherweight 12-point external wrenching locknut. Sizes #10 through ⅞ in.

*Designed for use in 2024T4 aluminum. †Lightweight configuration for use in 7075T6 aluminum or harder materials.

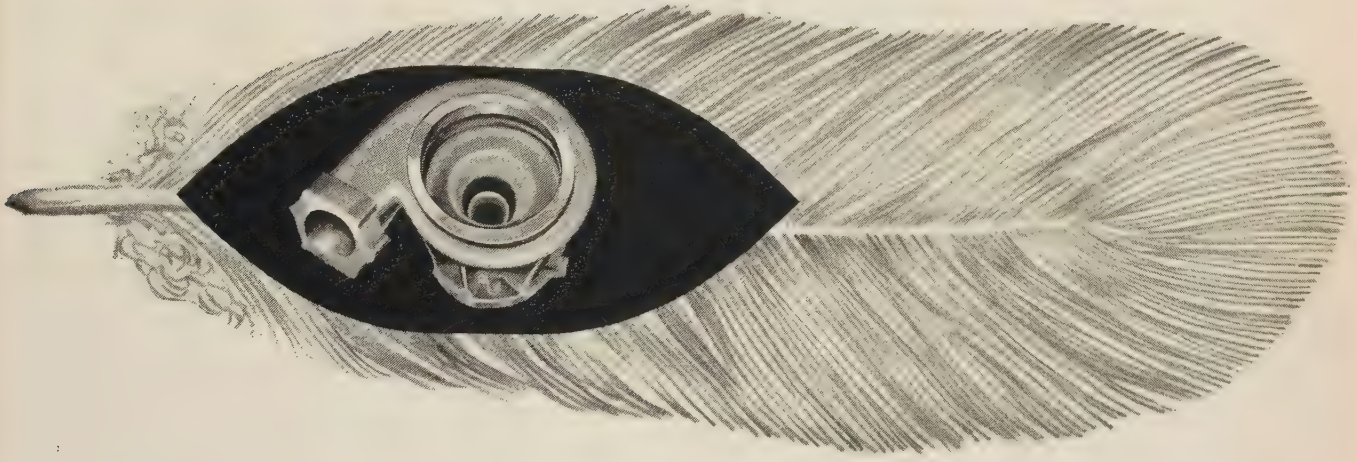
Tension bolts and locknuts shown (a fraction of the complete SPS line) are serviceable to 550°F. Other combinations are available for service through 1600°F. Whatever your particular need, SPS can offer a performance-matched bolt and locknut assuring a joint of highly predictable performance. For further information, write SPS—manufacturer of precision threaded fasteners and allied products in many metals, including titanium.

AIRCRAFT / MISSILE Division SPS

JENKINTOWN 54, PENNSYLVANIA • SPS WESTERN, SANTA ANA, CAL.

Write in No. 22 on Reader Service Card at start of Product Preview Section

new weight saving material for missiles and high performance jet aircraft



NEW HIGH-STRENGTH . . .
HIGH-PURITY ALUMINUM CASTING ALLOY

If you've been pushing A-356 to the limit of its physicals to scrape off every possible ounce of excess weight . . . then new alloy MA-356 was made to order for you. With a few minor changes in chemical composition, Rolle has produced what is essentially a new casting material. Highly responsive to heat treatment, it permits higher tensile strength, higher yield strength, and greater elongation. Rolle is pouring MA-356 now . . . in castings that consistently exceed the physical requirements of MIL-C-21180A. Check, for example, the typical sand cast range of properties MA-356 permits in the T-6 condition against what you can expect from conventional A-356 at left:

ALLOY (T-6)	U.T.S. (psi)	Y.S. (psi)	E (%)
A-356	40,000	30,000	3
MA-356			
minimum	40,000	30,000	5
maximum	50,000	40,000	2

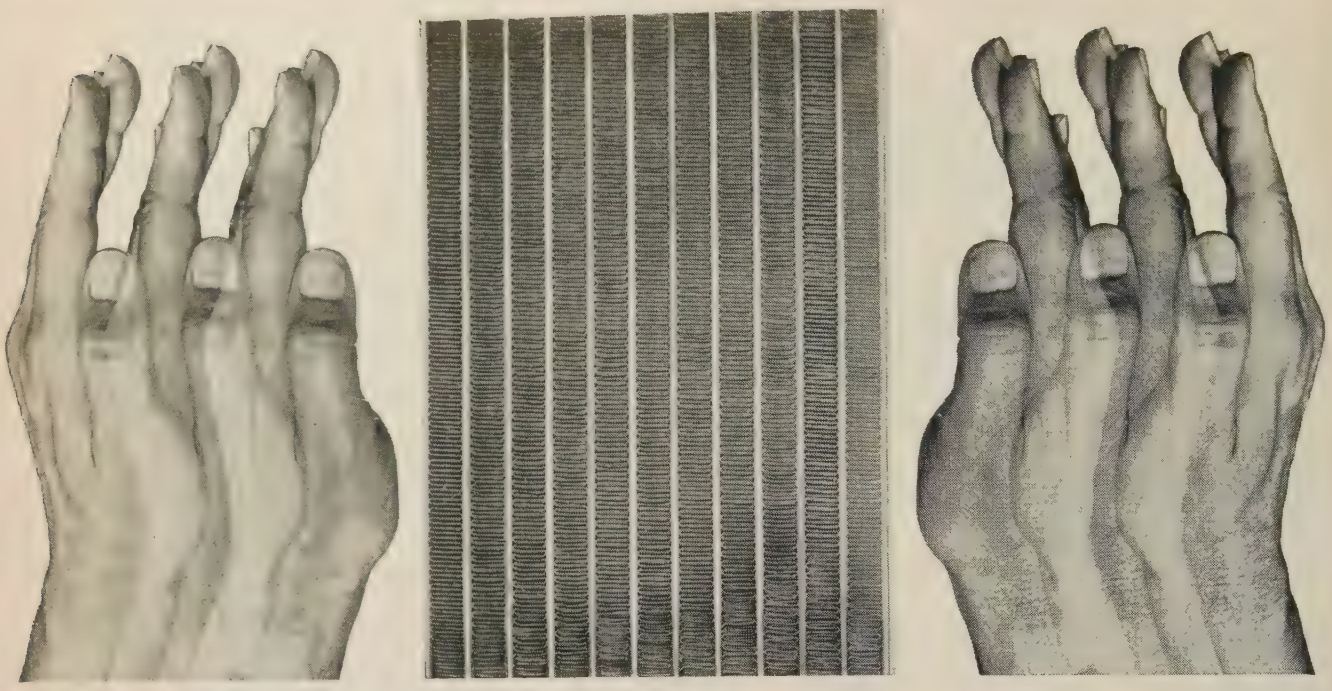
One of the advantages of MA-356 is that any desired physical within the typical range can be emphasized through careful control of heat treatment of the casting. Even more exciting are the extremely high physicals that have been achieved with MA-356 in favorable casting configurations. Test castings have actually exceeded a tensile strength of 54,000 psi and yield strength of 44,000 psi with 2% elongation.

But no two castings are alike. It's impossible to predict the benefits MA-356 will confer on your sand and permanent mold castings without prints and specs. If you'd like more information on this new alloy, write for Technical Data Bulletin 1001. And when you do, why not ask for your copy of our 58-page light metals casting handbook . . . an engineering guide to aluminum and magnesium sand and permanent mold castings. Rolle Manufacturing Company, 301 Cannon Avenue, Lansdale, Pennsylvania, or call ULysses 5-1174.

ROLLE

Write in No. 150 on Reader Service Card at start of Product Preview Section

WHAT SIZE WILL YOUR



HEAT EXCHANGER BE?

UAP's New Program of Core Fabrication Provides Envelope Dimensions IN HOURS!

Now you can save days or even weeks of pre-design time by telephoning your proposed heat exchange requirements direct to UAP! Within a few hours, UAP can furnish exact envelope dimensions for heat exchangers of required capacity.

Accurate and time-saving answers to dimensional problems are but one significant advantage to UAP's new method of heat exchanger core fabrication. By simplifying core design, UAP's new assembly procedure assures positive, trouble-free bonding of all flow-way configurations.

UAP's famous dip-brazing process produces standard heat-treatable cores of highest "aircraft quality," comparable to finest custom core designs. These completely new heat transfer units can be applied wherever liquids or air are utilized as the ultimate heat sink to remove heat from other liquids or air.

Let us quote dimensional figures for the pre-design planning of your next development!

Call or write contractual engineering:

CALIFORNIA.....1101 Chestnut St., Burbank, VI 9-5856
NEW YORK.....50 E. 42nd St., New York 17, MU 7-1283
OHIO.....1116 Bolander Ave., Dayton, BA 4-3841
CANADA.....United Aircraft Products, Ltd., 147 Hymus Blvd., Pointe Claire, P.Q., Phone Montreal: OX 7-0810

UAP — UNITED AIRCRAFT PRODUCTS, INC. ®

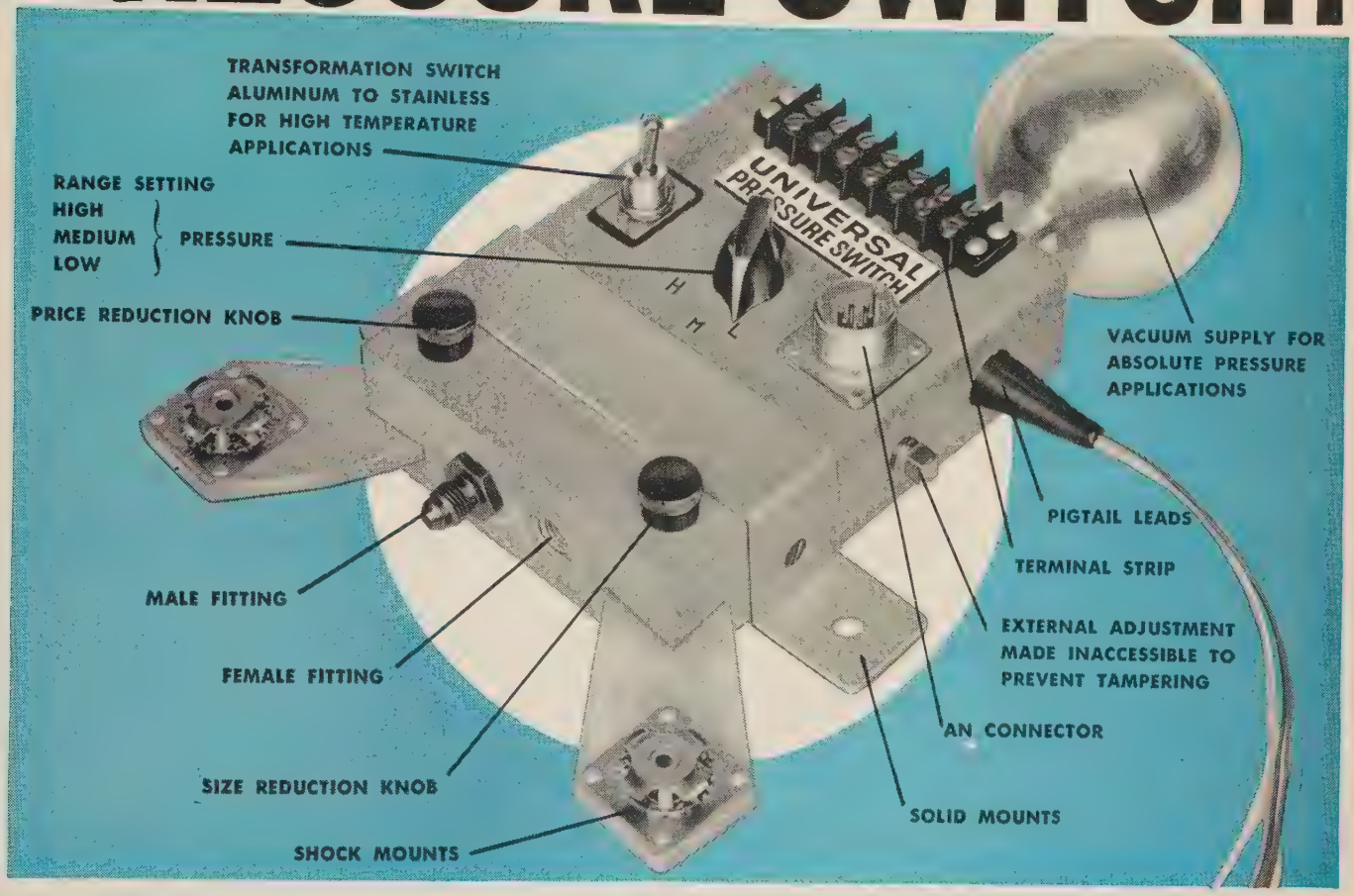
a famous family of aircraft essentials since 1929

UNITED AIRCRAFT PRODUCTS, INC.

1116 BOLANDER AVENUE, DAYTON, OHIO

Write in No. 149 on Reader Service Card at start of Product Preview Section

A UNIVERSAL PRESSURE SWITCH!



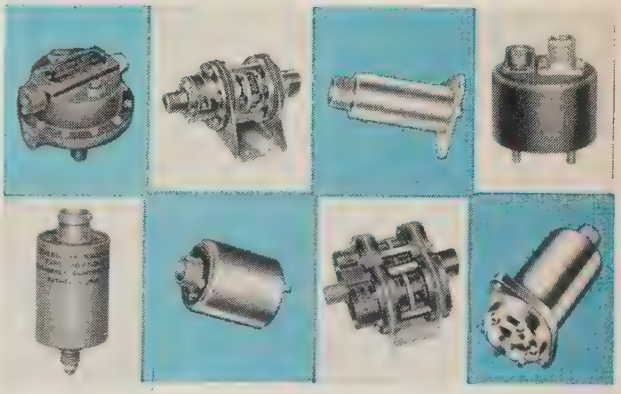
After years of analyzing thousands of pressure switch specifications, our engineering department concludes that one UNIVERSAL design will fulfill 33.7% of all requirements.

For the other 66.3% of pressure switch applications where the universal switch won't do, we suggest rummaging about in our catalog which tells of a full line of "standards" now in production.

AND, if you happen to have a really weird problem (currently 6.93% of all inquiries) which can't be answered by one of our standards, write to us anyway. We keep a few odd engineers who thrive on the off beat applications.

Please direct all inquiries to the Sales Department where they will be judged impartially on the basis of clarity, sincerity and volume potential. Those inquiries which clearly demonstrate a "need to know" will be answered promptly.

"FROM INCHES OF WATER
TO HUNDREDS OF ATMOSPHERES"

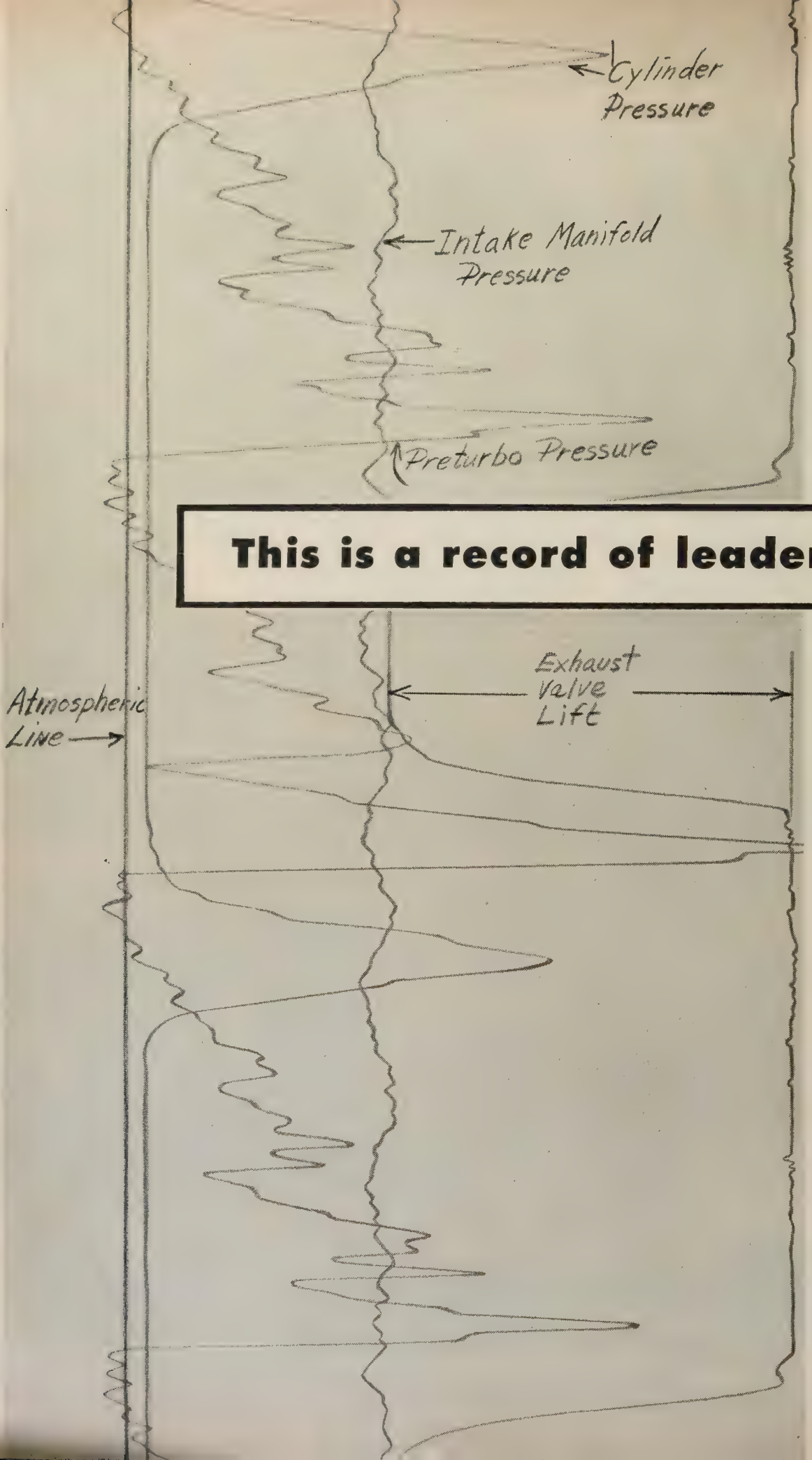


CONSOLIDATED CONTROLS CORPORATION

BETHEL, CONN., INGLEWOOD, CALIF.

A SUBSIDIARY OF CONSOLIDATED DIESEL ELECTRIC CORPORATION

Write in No. 204 on Reader Service Card at start of Product Preview Section



This is a record of leadershi

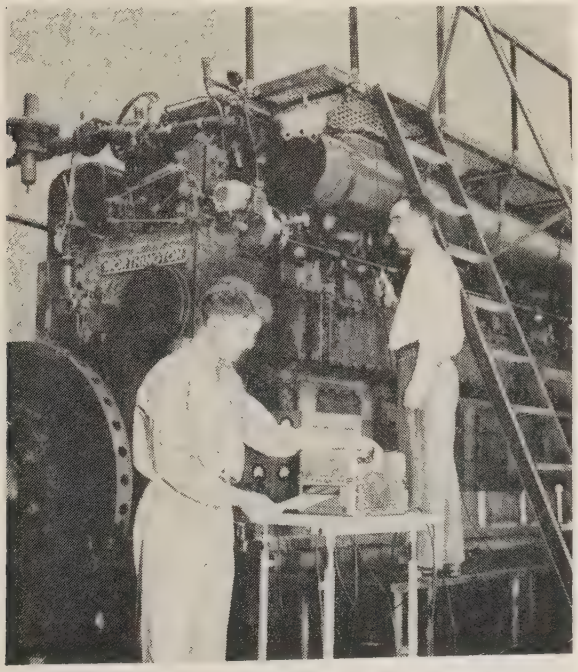
The Worthington Corporation used a Honeywell 906 Visicorder to chart the heartbeat of a Worthington Tripower diesel engine. These Tripower (oil fuel, dual fuel, or spark ignition gas) engines have a fourteen inch bore, an eighteen inch stroke, and develop more than 265 h.p. per cylinder at 450 RPM.

The Visicorder used in these tests makes a direct, instantly-readable record of the pressure variations in the exhaust manifold, cylinder, and intake manifold to determine optimum valve timing and engine configuration. The Visicorder also produces a permanent record of strain gauge measurements taken on the frame and other critical engine parts.

For the manifold and cylinder pressures, strain gauge pressure transducers and a strain gauge amplifier were used. For the valve lift patterns, a linear potentiometer powered with a small battery was connected directly to the Visicorder.

Analysis of these data has led to changes in the Tripower engine for best performance.

in diesel engine research



Ted Dupler (left) and John McAllister, Worthington Engine Research Engineers, measure intake manifold, cylinder, and exhaust manifold pressures and valve stroke on a Tripower with a Honeywell 906 Visicorder.

The Honeywell Visicorder is the pioneer and unquestioned leader in the field of high-frequency, high-sensitivity direct recording oscillography. In research, development and product testing everywhere, instantly-readable Visicorder records are pointing the way to new advances in product design, rocketry, computing, control, nucleonics . . . in any field where high speed variables are under study.

The new Model 906A Visicorder, now available in 8- and 14-channel models, produces longitudinal grid lines simultaneously with the dynamic traces, time lines, and trace identification by means of new accessory units.

To record high frequency variables—and monitor them as they are recorded—use the Visicorder Oscillograph. Call your nearest Minneapolis-Honeywell Industrial Sales Office for a demonstration.

Reference Data: Write for Visicorder Bulletin
Minneapolis-Honeywell Regulator Co.,
Industrial Products Group, Heiland Division
5200 E. Evans Ave., Denver 22, Colo.

Honeywell

Industrial Products Group

Write in No. 153 on Reader Service Card at start of Product Preview Section

THIS ENGINEER HAD RIGID BOREDOM

That's the next step to rigor mortis, you know, and is very, very serious. It's caused by an overdose of routine.

How'd he cure himself? By coming over to RCA Service Company, naturally—where a value is placed on versatility, not just the ability to add and subtract. Here you grow and grow, because you work with top men on many-faceted assignments that'll keep *anybody* stepping. And the best thing about it is, you work as an individual, applying your own ideas and initiative to projects *right in the field.* You get full satisfaction from a *complete* job well done.

If you're an electrical or mechanical engineer suffering from rigid boredom, it's high time to "take the cure." First step: send a résumé to Mr. James Bell, Employment Manager, Dept. Y-19G RCA Service Company, Cherry Hill, Camden 8, N. J.

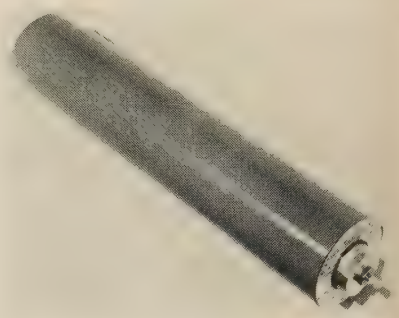
EQUAL JOB OPPORTUNITY For All Qualified Applicants

RCA SERVICE COMPANY

A Division of Radio Corporation of America

Check Employment Inquiry Form on Page 157

PISTON ACCUMULATOR is leakproof

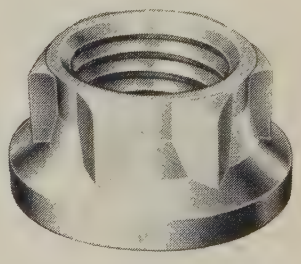


Long seal life with no air or oil leakage is featured in this piston accumulator, says **The Narda Hydraulics Corp., Dept. S/A, 122 Hericks Rd., Mineola, N.Y.** The unit also reduces horsepower requirements when service is intermittent, reduces system surges, and provides a source for emergency power in case of system failure.

The Model 30001, for industrial applications, has a free piston with three O ring seals. Any air or oil trapped between two given seals is automatically discharged to its respective chamber during each piston stroke. End caps use the same size O ring seals as the piston. Other models are available for aviation applications.

Write in No. 263 on Reader Service Card

SELF-LOCKING NUT for short-thread screws



This Kaylock H14 low-height, self-locking nut, designed for 160,000 psi short-thread screws and bolts offers a 20 to 42% weight reduction over previous series. Wrenches are also two sizes smaller, permitting the use of narrower flanges and allowing the bolt to be placed closer to load centerline, says **Kaynor Mfg. Co., Dept. S/A, Box 2001, Terminal Annex, Los Angeles 54, Calif.**

This product is said to meet need for a stronger low-height nut to complement higher tensile fasteners. It is available in A286 corrosion-resistant steel for 900° F.

Write in No. 264 on Reader Service Card

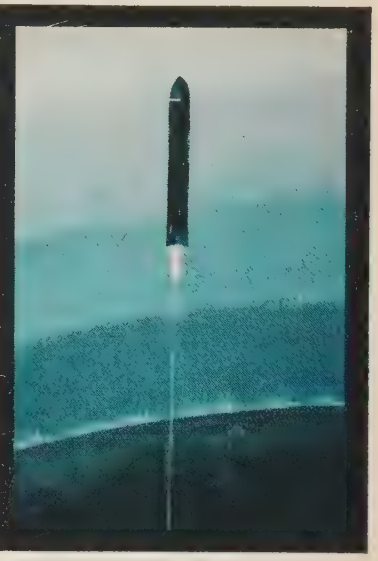
more on page 216

To further serve the diversified missile industry

MINNESOTA MINING and MANUFACTURING COMPANY

announces and offers the services of its

MISSILE INDUSTRY LIAISON



More than 27,000 products are manufactured by Minnesota Mining and Manufacturing—the 3M Company. Every day, more and more 3M products are playing important parts in missile and space operations.

The technical and sales staffs of some fifteen 3M divisions, subsidiaries and groups make daily contacts with missile manufacturers and subcontractors. Their efforts are implemented by 22 divisional and four staff research laboratories.

However, like the missile industry, the 3M Company is a growing *and a diversified* operation. The use of 3M products and capabilities increases every day.

To further serve this growing, diversified industry, 3M has formed the Missile Industry Liaison. This group, staffed by technical personnel experienced in rocket propulsion and other phases of space technology, is well qualified to translate *your problems* to those 3M specialists in your field of interest. Too, information on all 3M Company products—or interests applicable to missile research, development or production—is thus available to you through *one* convenient source.

For a cross-section view of 3M Company products for the industry, send for your free copy of the brochure "Products and Capabilities." Write: Missile Industry Liaison, 400 McKnight Road, St. Paul 6, Minnesota.

The Missile Industry Liaison is associated with these 3M divisions and subsidiaries:

Zenith Plastics Company
Reinforced Plastics Division
Electrical Products
American Lava Corporation
Irvington Division
Mica Insulator Division
Magnetic Products Division
Central Research Group
Mincom Division
Duplicating Products Division
Reflective Products Division
Industrial Trades Tape Division
Mid-States Gummed Paper Division
Chemical Division
Adhesives, Coatings, and Sealers Division

For more information on 3M products, contact your 3M representative or the Missile Industry Liaison, 400 McKnight Road, St. Paul 6, Minn.

MINNESOTA MINING AND MANUFACTURING COMPANY
...WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

MISSILE INDUSTRY LIAISON

Write in No. 154 on Reader Service Card at start of Product Preview Section

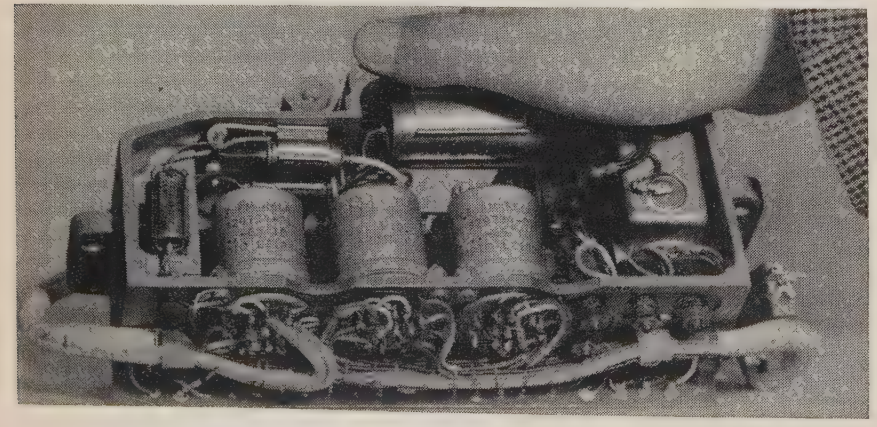
Union Relays meet all requirements of Talos guidance system

The Talos, the Navy's long-range guided missile, is very important to the nation's defense. And Bendix Aviation Corporation, builder of the Talos, chose a relay made by Union Switch & Signal to meet the *extreme reliability* needs of that missile's guidance control system. That relay is the UNION miniature 6PDT.

Its clean, simple, *rotary* design gives it fewer inherent problems than other relays. Probability of flight failure of a contact pair is only once in 600,000 operations. In vibration tests, it is absolutely solid to 2,000 C.P.S. at 15G. In temperature tests, it has performed reliably for six minutes at up to 177°C.

Union Switch & Signal makes a complete line of *dependable* miniature relays, manufactured to meet MIL-R-25018, MIL-R-6106C, and MIL-R-5757C requirements. Advanced design and close quality control have made Union Switch & Signal a leading supplier of relays for missile control. Write today for complete technical information.

Three UNION miniature 6PDT relays positioned in part of the Talos guidance control system.

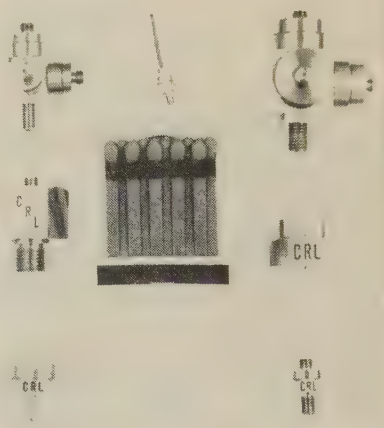


"Pioneers in Push-Button Science"

UNION SWITCH & SIGNAL
DIVISION OF WESTINGHOUSE AIR BRAKE COMPANY
PITTSBURGH 18, PENNSYLVANIA

Write in No. 155 on Reader Service Card at start of Product Preview Section

ACCELEROMETERS for high temperatures



These crystal accelerometers operate in an ambient temperature range between −65° F and 540° F without cooling or correction and utilize a piezo-electric crystal in a true compression type seismic system to provide an accuracy ±5% over broad acceleration and frequency ranges. The line ranges from heavy duty to sub-miniature models with sensitivities from 30 mv/g to 1 mv/g. Natural frequencies from 65 kc to 150 kc resulting from the design of the system and the construction of the case permit broad frequency coverage without spurious signals from resonance effects, says **Columbia Research Laboratories, Dept. S/A, McDade Blvd. & Bullens Lane, Woodlyn, Pa.**

The models are capable of producing a linear output over a frequency range to 8 kc.

Write in No. 265 on Reader Service Card

RADARS for target tracking

These mobile fire control radars for medium or heavy anti-aircraft guns are designed for automatic detection and tracking of targets, says **Compagnie Francaise Thomson-Houston, Dept. S/A, 173 Bd., Haussmann, Paris 8, France.** The TH. D. 1210 for heavy guns can detect targets up to a range of 64 km, and it provides automatic tracking within a 45-km range; range error is said to be ten m over the tracking range.

The TH. D. 1225, for medium artillery, provides autonomous search, acquisition and radar tracking within an alarm zone with a 30-km radius. It has a transmitter frequency adjustable within the 8900 to 9500-mc band, and it uses a repetition rate of 2000 pps. The TH. D. 1210 has an operating frequency of 2700 to 2900 mc, and it uses a repetition rate of 1500 pps. Both equipments use a 0.5-usec pulse width.

Write in No. 266 on Reader Service Card

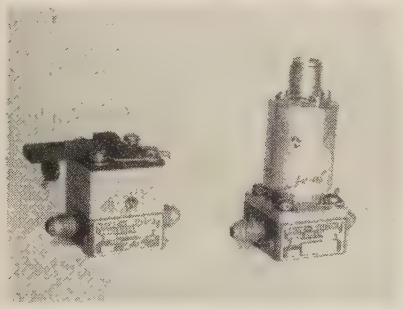
LOCKNUT *is featherweight*

A high-strength locknut for use at temperatures up to 1200 deg F is as much as 57 per cent lighter than the conventional 1200-deg standard, according to **Standard Pressed Steel Co., Dept. S/A, Jenkintown, Pa.** The FN 1216, intended for structural applications on aircraft and missiles, has a minimum tensile strength of 200,000 psi at room temperature and over 150,000 at 1200 deg F.

The locknut reportedly can be mounted significantly closer to corners and perpendicular bulkheads and generally permits smaller bolt circles in flange applications. The device is available in four diameter sizes, including #10-32 through ⅜-24.

Write in No. 267 on Reader Service Card

FLUID VALVES *isolate mechanism*



These exotic and corrosive fluid valves, manual and solenoid "on"-"off" to 500 psi, keep the operating mechanism totally isolated from internal media and external environments. Internal media cannot corrode, gum or bind operating mechanism, says **Pneu Draulics, Inc., Dept. S/A, 1294 E. 3rd St., Pomona, Calif.**

Standard valve is ¼" tube size. Absolute zero leakage guaranteed.

Write in No. 268 on Reader Service Card

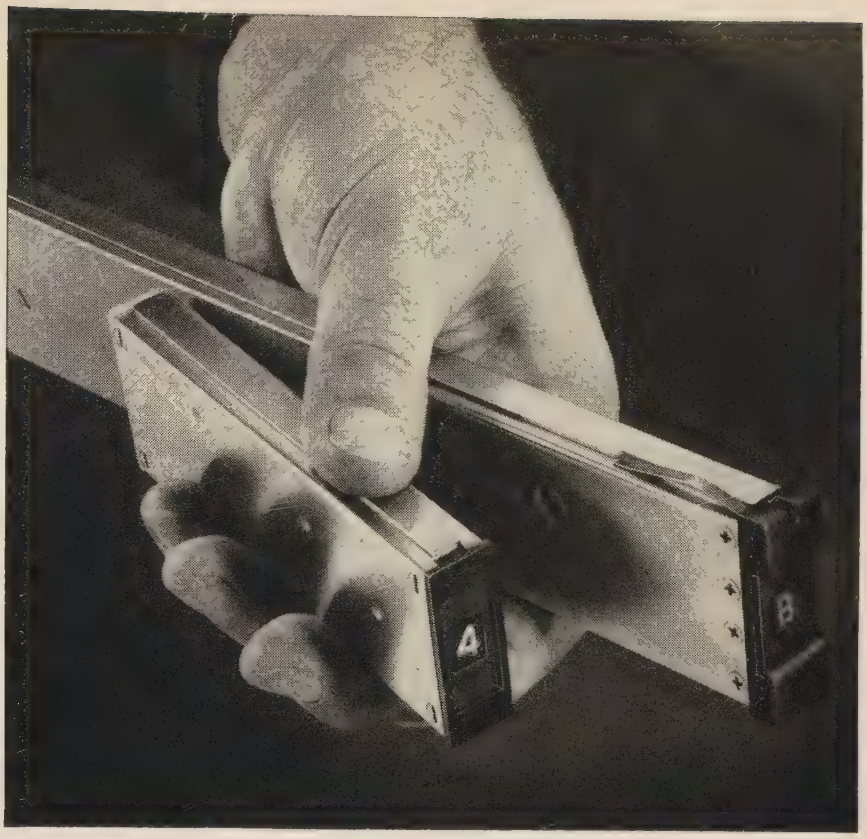
METAL COATING *eliminates sandblasting*

Costly sandblasting surface preparation of metals can be eliminated through use of a phenolic-vinyl system of maintenance coatings, according to **Union Carbide Plastics Co., Dept. S/A, 655 Madison Ave., New York 21, N.Y.** Only wire brushing of the surface is required before the phenolic-resin-based primer and vinyl top coat are applied.

Extensive testing of exposure panels in and out of industrial areas, as well as two years of industrial use, have shown that the gloss retention and durability of the vinyl top coat augments the high corrosion resistance and adhesion of the phenolic primer.

Write in No. 269 on Reader Service Card

more on next page



Compact! Easy to Read! READALL† Readout Instruments

Union Switch & Signal makes two types of electro-mechanical, DC-operated readout instruments, displaying 10, 12, or 16 characters on a wheel; or displaying up to 64 characters on a MYLAR* belt. Character assignments can be furnished as required.

TRANSLATION Both readout instruments operate directly on binary codes on a null-seeking basis. This eliminates the need for external equipment for translation from binary to decimal code, as required with other readout devices.

VISUAL READ-OUT Union readout instruments are designed for quick, easy readability, even when mounted in rows.

INFINITE RETENTIVITY These instruments require power only during the response time, because they are of the null-seeking type. Once positioned, they *retain* the data visually and electrically until a new code is received.

ELECTRICAL READ-OUT The design of the decoding and control portions of the readout instruments provides electrical read-out of data in the same form as the input. The data can be read continuously or periodically without erasing the stored information.

USES Union Switch & Signal READALL readout instruments can be used in the output of digital computers, in teletype receiving equipment, in telemetering systems, or wherever data needs to be displayed.

†*Trademark* **Dupont's synthetic fiber.*

Write for complete information.

"Pioneers in Push-Button Science"

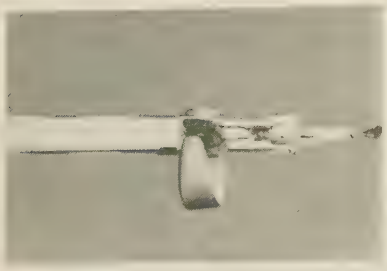
UNION SWITCH & SIGNAL

DIVISION OF WESTINGHOUSE AIR BRAKE COMPANY

PITTSBURGH 18, PENNSYLVANIA

Write in No. 156 on Reader Service Card at start of Product Preview Section

HIGH VACUUM GAGE uses ionization



This high-vacuum gage operates on a pressure measurement principle of the cold cathode, said to be the ionization of gas molecules present in a vacuum system. This model 100-A gage consists of the power supply and a front panel housing the six-position range switch and the meter, mounted on a standard 19" chassis, according to **Miller Laboratories, Dept. S/A, P. O. Box 97, Brea, Calif.**

Applications include hermetic sealing, vacuum tube pump-down systems, metal evaporation, mass spectrometry, vacuum distillation, vacuum metal refining, and as a general laboratory instrument wherever low pressure measurements are required.

Write in No. 270 on Reader Service Card

RF CHOKE KITS for designers

These 3 RF choke kits, containing a total of 63 chokes in a preferred series of inductance values ranging from 0.1 to 10,000 uh, are available from **Essex Electronics, Dept. S/A, 550 Springfield Ave., Berkley Heights, N.J.J**

Series S kit contains 19 chokes in a range of 0.1 to 100 uh; series M kit contains 19 chokes from 1.0 to 1000 uh; and series L kit contains 25 chokes from 1.0 to 10000 uh.

Write in No. 271 on Reader Service Card

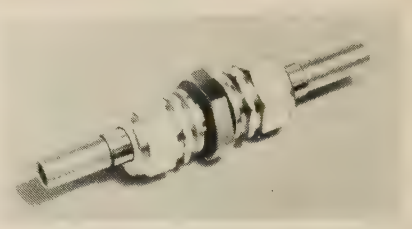
RETAINING RINGS of new alloy

PH15-17Mo alloy, a high strength precipitation hardening stainless steel, is being used to give Truarc retaining rings unusual corrosion resistance at temperatures up to 1000 deg F, says **Waldes Kohinoor, Inc., Dept. S/A, 47-16 Austel Pl., Long Island City 1, N.Y.** The rings are now available in six metals, including aluminum, beryllium copper, and phosphor bronze.

The new stainless is suggested for rings used in aircraft and missile parts.

Write in No. 272 on Reader Service Card

SELF-LOCKING NUT for fluid systems



This one-piece self-locking coupling nut for hydraulic lines is said to insure vibration-proof tightness and greater reliability in critical fuel, oil and refrigerant lines. It is adaptable to either flared or flareless methods of tube sealing. Unaffected by oils, this CN-8 series, said to be the first self-locking nut, are of stainless steel usable to 800° F working temperatures; steel, to 550° F. They are interchangeable with AN 808 and MS 21914 series coupling nuts, says **Standard Pressed Steel Co., Dept. S/A, Jenkintown, Pa.**

The series has met extensive qualification tests based on locking torque requirements of Specification MIL-N-25027.

Write in No. 273 on Reader Service Card

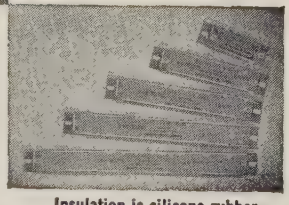
more on page 222

New
POWER RESISTORS
for FLIGHT USE

ELECTRO-FLEX
specialists in HEATING ELEMENTS

LESS SPACE—LESS WEIGHT

New lightweight, space-saving resistors permit substantial efficiencies and economies in aircraft and missile electronic apparatus. Units are mounted in direct contact with inner surface of chassis or case so that 25% to 40% of heat generated is emitted to atmosphere. Derating curves are available.



Available in the following ratings and sizes

Power Rating	Envelope Dimensions	Approx. Weight
40 Watts	7/32 x 1 5/16 x 4	.027 lbs. ea.
80 Watts	7/32 x 1 5/16 x 6	.040 lbs. ea.
120 Watts	7/32 x 1 5/16 x 8	.053 lbs. ea.
160 Watts	7/32 x 1 5/16 x 10	.067 lbs. ea.
200 Watts	7/32 x 1 5/16 x 12	.080 lbs. ea.

Insulation is silicone rubber—operable continuously at 450° F.
Mounting metal—Alclad aluminum.
Connection tabs—silver plated brass.

Special washers permit bolt or rivet mounting. Adhesive supplied provides good thermal transfer from resistor to mounting wall.

send for free illustrated booklet

Electro-Flex Heat, INC.
83 WOODBINE ST., HARTFORD, CONN. (CHapel 6-5413)
"FIRST with STANDARD ELEMENTS"

Write in No. 157 on Reader Service Card

this NO-COST TEST OFFER has CONVINCED thousands
. . . send for YOUR FREE "TEST CAN" of C-5 "hi-temp" ANTI-SEIZE THREAD COMPOUND!

For one hunderd and one aircraft uses such as slip joints, spark plugs, manifold studs, turbo blowers, jet engines, etc.

Try C-5 and see why leading aircraft manufacturers and thousands of industrial users have made it a part of their regular preventative maintenance program.

FEL-PRO C-5 "HIGH-TEMP"

- ✓ Ends Seizing and Galling even up to 1800°F.
- ✓ Reduces Wrench Torque
- ✓ Ends Stud Breakage
- ✓ Permits Repeated Re-use
- ✓ Speeds Assembly and Disassembly
- ✓ Protects Stainless Steel at all Temperatures

1614-AR

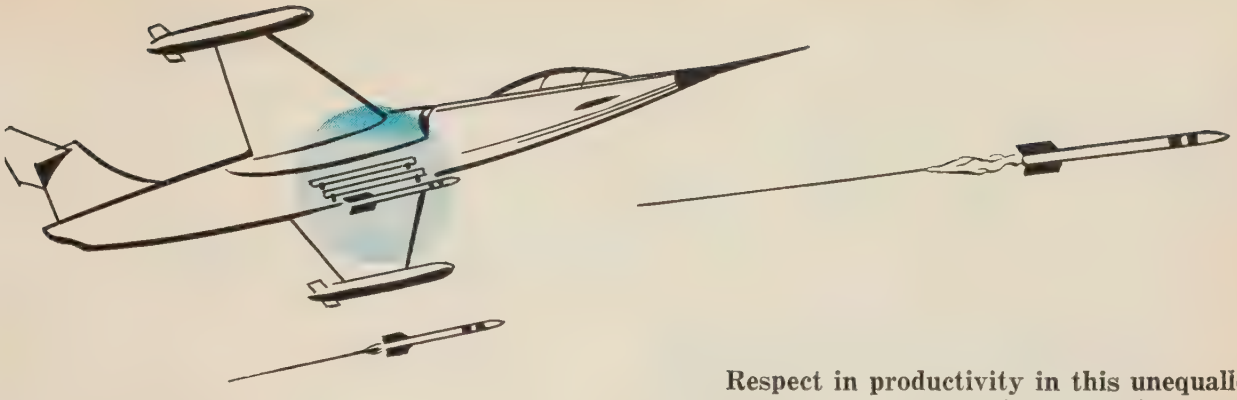
ANTI-SEIZE THREAD COMPOUND

C-5's exclusive colloidal copper formula separates mating metal threads and surfaces with cushioning, protective copper plating. C-5 prevents galvanic action and eliminates pitting even when dissimilar metals join. On mating metal surfaces, C-5 saves gaskets and countless man hours.

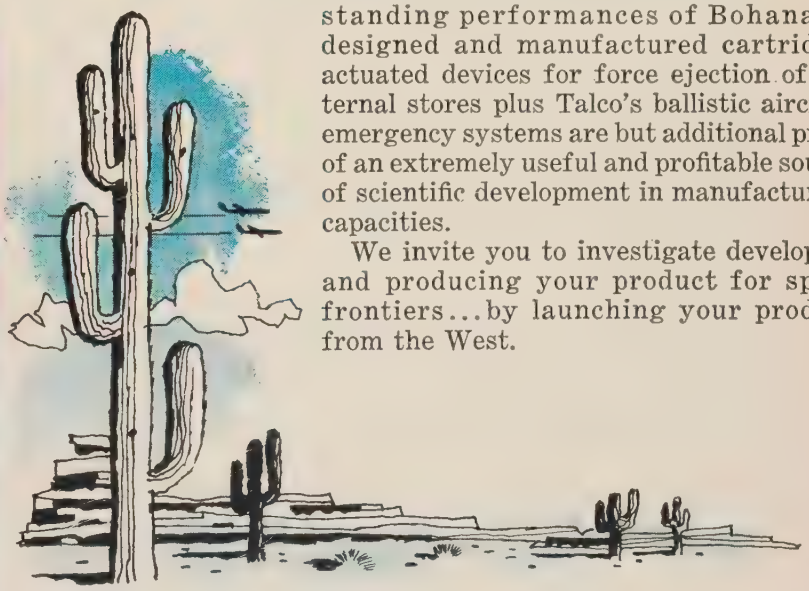
WRITE TODAY . . . For Your FREE Test Sample Can of C-5.

FELT PRODUCTS MFG. CO.
Dept. 52, P.O. Box 8609
Chicago 80, Ill.

Write in No. 158 on Reader Service Card



Ask anyone in the West...



Respect in productivity in this unequalled space-age era depends on consistent reliability in the design and manufacture of precision components.

The GABRIEL Company, combining its rich technological heritage, adds the outstanding resources in aircraft and missile research and talents in its affiliates BOHANAN Manufacturing Company and TALCO Engineering Company.

In the technological laboratories of these partner firms are provided the total concept approach to ground and space problems... the ability to integrate brainpower and components constantly meeting the even greater challenges of the future. The outstanding performances of Bohanan's designed and manufactured cartridge-actuated devices for force ejection of external stores plus Talco's ballistic aircraft emergency systems are but additional proof of an extremely useful and profitable source of scientific development in manufacturing capacities.

We invite you to investigate developing and producing your product for space frontiers...by launching your product from the West.

Bohanan
BOHANAN MFG • DIVISION

Talco
TALCO ENGR • SUBSIDIARY

Gabriel

15800 SOUTH AVALON BOULEVARD, COMPTON, CALIFORNIA
FAculty 1-4200 • DAvis 3-4331

Write in No. 159 on Reader Service Card at start of Product Preview Section

LOOK FOR THE DIAMONDS—SIGN OF FINISHING QUALITY

NOW—A Great New Combination for DOUBLE PROTECTION Against Corrosive Conditions on Aluminum, Magnesium or Zinc

IRIDITE®
CHROMATE CONVERSION COATINGS
and
IRILAC™
CLEAR PROTECTIVE COATINGS

Now, here's a fast, easy, economical way to almost double the protection against corrosion on your product. Simply follow up the IRIDITE process with a fast, easy application of IRILAC . . . and you've given your product extra protection for longer resistance to corrosive conditions, longer shelf or storage life, protection from handling and increased beauty for more attractive appearance and faster sales.

ON ALUMINUM

An IRIDITE-IRILAC finish will provide longer life for storm doors, windows, outdoor furniture, auto parts and accessories, tubing or wire goods. And, you have a choice of color finishes such as natural aluminum and golden yellow. Other colors may be obtained by an additional dye operation.

ON MAGNESIUM

IRILAC over an IRIDITE No. 15 finish increases corrosion protection, and provides resistance to finger printing and abrasion on all types of products, with color appearance ranging from light to dark brown.

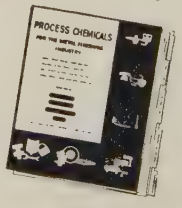
ON ZINC

IRIDITE plus IRILAC gives your product longer life and brighter appearance. Color choices range from the bright IRIDITE finish, a clear finish, through yellow iridescent to military olive drab, in addition to colored dye finishes.

IRIDITE is the tradename for a specialized line of chromate conversion coatings that can be applied to any non-ferrous metal by brush, dip or spray methods—at room temperatures—manually or with automatic equipment. Upon application, a thin film forms which becomes an integral part of the metal itself, and thus cannot chip, flake or peel. No special equipment, exhaust systems or specially trained personnel are required.

IRILAC is the tradename for a line of clear protective coatings for all metals. As safe and easy to handle as water, they may be applied by brush, dip or spray methods. No exhaust or special fire protection equipment required. Adds protection and abrasion resistance to any base metal, plated part or parts treated with electrolytic or chemical post treatments, without chemical change.

For complete technical information on IRIDITE Chromate Conversion Coatings or IRILAC Clear Protective Coatings, write for FREE TECHNICAL MANUAL. Or, see the Allied Field Engineer in your area. He's listed under "Plating Supplies" in the yellow pages.



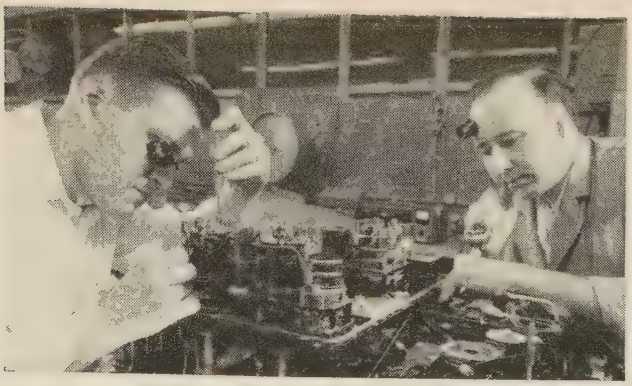
Allied Research Products, Inc.

4004-06 EAST MONUMENT STREET • BALTIMORE 5, MARYLAND
BRANCH PLANT: 400 MIDLAND AVENUE • DETROIT 3, MICHIGAN
West Coast Licensee for Process Chemicals: L. H. Butcher Co.

Chemical and Electrochemical Processes, Anodes, Rectifiers Equipment, and Supplies for Metal Finishing

IRIDITE® Chromate Coatings	IRILAC™ Clear Coatings	ISOBRITE® Plating Brighteners	ARP® Chemicals & Supplies	WAGNER Line of Equipment

Write in No. 161 on Reader Service Card at start of Product Preview Section



How knowmanship pays— even before the presentation

When a prospective prime contractor makes his presentation, success or failure can depend in great part on the capabilities of his associate contractors. This is true not only in the important areas of sub-system development and cost forecasting, but equally so in developing a complete, convincing presentation.

Long *before* the presentation is made, the value of Eclipse-Pioneer's KNOWMANSHIP begins. For our rich experience enables us to help "primes" develop and present the facts pertaining to specific Weapons System capabilities.

KNOWMANSHIP is nothing more nor less than the name we've given our unique combination of technical knowledge, experienced management and specialized craftsmanship which, time and time again, has proved itself to prime contractors.

Eclipse-Pioneer's KNOWMANSHIP stems from over forty years' experience in developing and manufacturing top quality aircraft subsystems and components. Among these are Primary and Automatic Flight Control Systems, Inertial Guidance, Air Data and Navigational Computer Systems, and Stable Platforms. Then, too, there's our unmatched background as associate contractor to "primes", dating from the very first contract awarded under the Weapons System concept. Among the companies with whom we've worked on Weapons System contracts are Convair (for the Air Force), Martin (for the Army), and Douglas (for the Navy).

Behind our KNOWMANSHIP stand 9,000 engineers and other skilled workers and craftsmen, and well over a million square feet of plant space. It all adds up to one thing—Eclipse-Pioneer is more than "just another" associate contractor. E-P is a *professional partner* for prime contractors on advanced aircraft and missile development and production.

Our representatives are at your service whenever and wherever you have a project to discuss. Call, write or wire.

ECLIPSE-PIONEER

TETERBORO, N. J.
DIVISION of
Bendix
AVIATION CORPORATION

AUTOMATIC FLIGHT CONTROL • CENTRAL AIR DATA SYSTEMS • SPECIALIZED INSTRUMENTATION • NAVIGATION COMPUTERS AND DIRECTORS
STABLE PLATFORMS • INERTIAL GUIDANCE • RADAR ANTENNA STABILIZATION AND TRACKING SYSTEMS • GROUND SUPPORT EQUIPMENT

Write in No. 160 on Reader Service Card at start of Product Preview Section

AIRBORNE ACCESSORIES CORPORATION RELIES ON KLIXON INHERENT OVERHEAT PROTECTORS

Among the many quality components that help assure dependable, safe operation of the Lockheed Prop Jet Electra is the oil cooler flap actuator produced by Airborne Accessories Corporation, Hillside 5, New Jersey. Because dependability is a must, Airborne uses KLIXON Protectors to guard motors against excessive temperatures.

Ernest A. Linke, chief motor engineer, has this to say about KLIXON Inherent Overheat Protectors:

"We use KLIXON *Protectors exclusively on our motors used on actuators for military and commercial aircraft as well as for missiles. We have found from experience that close cooperation between the motor designer and the motor protector supplier is one of the keys to reliable motor performance."*

For more information, write for new catalog KLIXON Inherent Overheat Protectors for High Performance Motors.

Western manufacturers — refer inquiries to Metals & Controls Corporation, Southern California Office . . . 232 North Lake Avenue, Pasadena, California . . . Telephone Ryan 1-4288.

METALS & CONTROLS

3707 FOREST STREET, ATTLEBORO, MASS., U. S. A.

A DIVISION OF TEXAS INSTRUMENTS INCORPORATED

Spencer Products: Klixon® Inherent Overheat Motor Protectors
Motor Starting Relays • Thermostats • Precision Switches • Circuit Breakers

Write in No. 162 on Reader Service Card at start of Product Preview Section

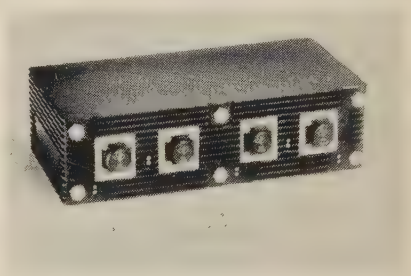
TRANSISTOR TESTER for beta measurements

Model 201 Transistometer measures small beta of NPN and PNP low power junction transistor in three ranges, 0 to 50, 0 to 250 and 0 to 500. The tester gives a direct reading of small signal beta by comparing the amplification factor of the transistor with a known attenuation factor, says **Hoover Electric Co., Dept. S/A, 2100 S. Stoner Ave., Los Angeles 25, Calif.**

The transistor under test is biased at V_{cb} 5 V, and the adjustable emitter current control provides a means of displaying beta vs emitter currents of 0.1 to 10 ma.

Write in No. 274 on Reader Service Card

POWER SUPPLY has three output voltages



Three separate output voltages can be supplied in airborne applications by the P/N 380-100 power supply, according to **Master Specialties Co., Dept. S/A, 956 E. 108th St., Los Angeles 59, Calif.** Voltages are: +150 V at 630 ma; —150 V at 100 ma; and —300 V at 40 ma.

The completely transistorized, 4.5-lb device closely regulates load and line variation. Design features include plug-in installation amd mounting of the power transistors on the cabinet for better heat transfer. The supply operates at full output rating at —85 deg C.

Write in No. 275 on Reader Service Card

BLIND RIVET sets seals in one step

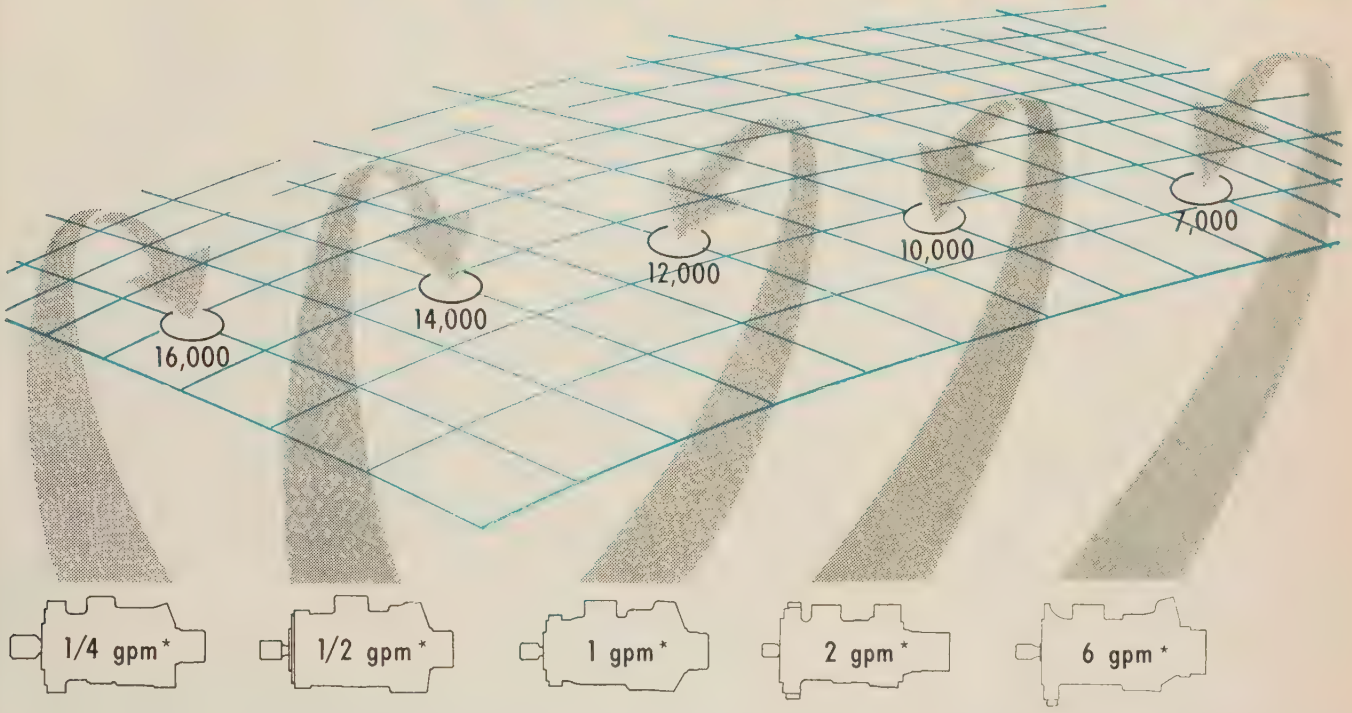
This blind rivet, called IMEX, is air and water tight at pressures as high as 500 psi and highly resistant to vibration. It is set by pulling a mandrel into the rivet shank, spreading and setting it. Radial expansion of the shank is balanced with shear strength criteria to ensure tightness under conditions of excessive vibration. Sealing is automatic, says **Pop Rivet Div., United Shoe Machinery Corp., Dept. S/A, W. Medway, Mass.**

The head of the mandrel is encased within the rivet and seats tightly against a shoulder formed during the setting operation.

Write in No. 276 on Reader Service Card

more on page 226

a new look at HIGH SPEED CAPABILITY in STRATOPOWER pumps



* Rated at 1500 rpm

These are what we've been calling "high speed" pumps.

But even "regular" models far surpass accepted speed standards

We used to distinguish "high speed" and "regular", BUT. . .

With STRATOPOWER "high speed" denotes not a specific group of models but a characteristic. No departure from basic design has been made to achieve high speed capability—STRATOPOWER engineers have simply "let out" the speed favoring factors inherent in a thoroughly tried and proved design. The experience gained with "high speed" pumps has readily been fed back into "regular" models.

Now the Barriers Are Down!

STRATOPOWER can provide "regular" 6 gpm pumps for limited life applications demanding 7,000 rpm and sound reliability — 50 highly satisfactory horsepower in a 16-lb. package! This and other new possibilities indicate that the old speed standards have been obsoleted.

You will be amazed at the speed ranges now available in an extensive selection of STRATOPOWER models.

Before dismissing any hydraulic application possibility on the basis of excessive speed requirement, check with your STRATOPOWER representative. He will be happy to discuss models and speeds in combinations you never before considered. It is possible that, in your specific application, even the speed shown above can be exceeded considerably.

Well qualified engineers in hydraulic and control design are invited to investigate their potential as a member of the STRATOPOWER organization. Please contact W. G. Watkins, Personnel Manager.

WATERTOWN DIVISION
THE NEW YORK AIR BRAKE COMPANY
STARBUCK AVENUE • WATERTOWN • N. Y.

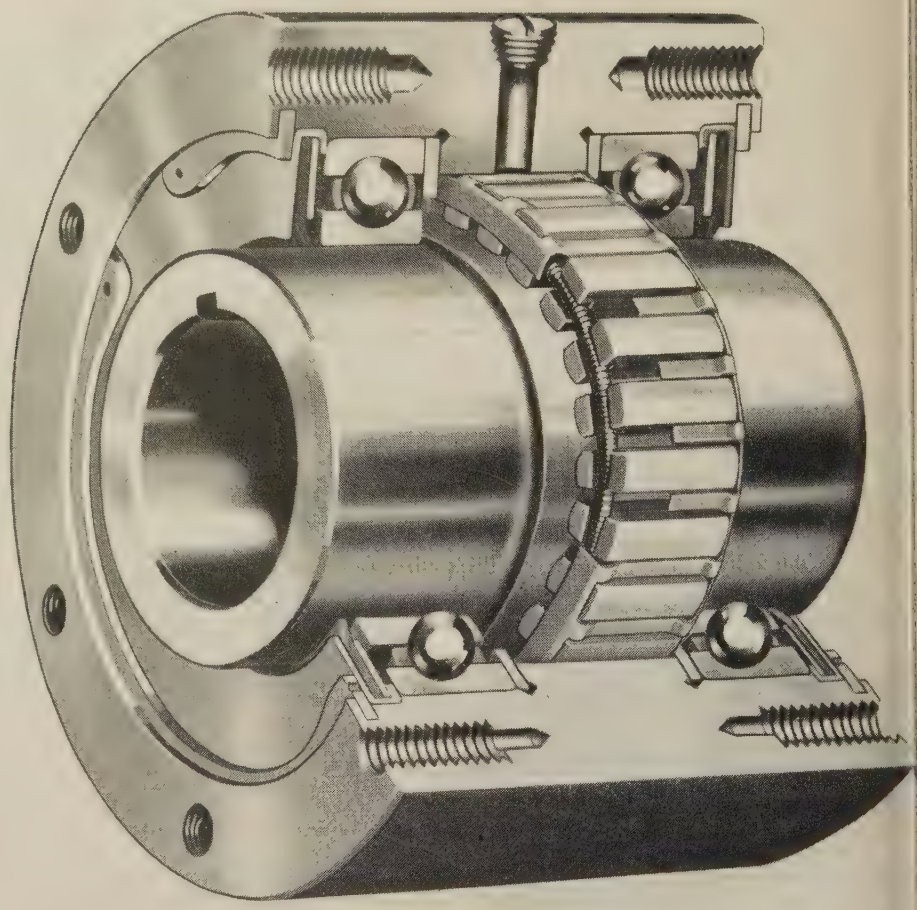
DALLAS OFFICE
The New York Air Brake Company
3323 Grove Street
Dallas 35, Texas

LOS ANGELES OFFICE
The New York Air Brake Company
5058 Venice Boulevard
Los Angeles 19, California

SEATTLE OFFICE
The New York Air Brake Company
Post Office Box 318
Bellevue, Washington

Write in No. 163 on Reader Service Card at start of Product Preview Section

NEW! HIGH-PERFORMANCE



This is a high-performance Formsprag clutch having a torque capacity of 475 lbs. ft. and a 1.25″ bore diameter. Note sprag and retainer design that assures coordinated yet free-action movement of sprags. Positive sprag engagement, greater torque capacity, higher speed applications and longer clutch life result from this new design.

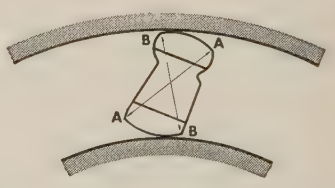
OVER-RUNNING · INDEXING BACKSTOPPING

COMPARATIVE PERFORMANCE CHARACTERISTICS

1. *Longer Life*—Running at identical speeds, an HPO clutch with Formchrome sprags will give you up to 70% longer life than a comparable standard Formsprag over-running clutch.
2. *Increased Speed*—HPO clutches using Formchrome sprags can be operated at up to 30% higher R.P.M. with same life span as a comparable standard Formsprag over-running clutch. Also, the HPO clutch design can be modified for special applications requiring high over-running speeds up to 20,000 R.P.M.
3. *High-Performance Indexing*—Here's a typical example that is characteristic of the entire HPI line. On 15° indexing, a Formsprag HPI clutch with a torque capacity of 475 lbs. ft. can be operated at 1,200 indexes per minute without slip or backlash.

For further information on these High-Performance Over-running and Indexing clutches, send for descriptive brochure.

HERE'S



The Formsprag clutch consists of a full complement of shaped sprags, or wedges, located between concentric inner and outer races. Power is transmitted from one race to the other by the wedging action of the sprags. Each sprag is so shaped that dimension AA is greater than BB. Rotation of one race in the "driving" direction causes the sprags to wedge, transmitting torque in full from one race to the other.

FORMSPRAG CLUTCHES

FOR OVER-RUNNING · INDEXING

Formsprag clutches have always provided greatest torque for size and weight, higher precision, no measurable backlash and long, trouble-free life. However, designers and users often have applications for over-running and indexing clutches where even higher performance characteristics are required.

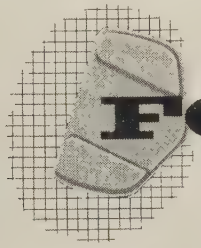
To meet this need for super-performance, Formsprag has perfected a new line of High-Performance Over-running (HPO) clutches and a new line of High-Performance Indexing (HPI) clutches.

The HPO and HPI clutches have an improved sprag design and retainers that assure a coordinated movement of all sprags but each sprag also has a free-action feature. The design assures: positive engagement of every sprag—uniform distribution of driving load over all sprags—greater torque capacity for clutch size. This same "Free-Action" operation of sprags also assures there will be a minimum of drag on all sprags during over-running. Result, clutch can operate at higher speeds, there is less wear on all clutch components and longer clutch life is obtained.

There is a Formsprag clutch size and model for every application—from business machines to aircraft. HPO, HPI and standard FS clutches are completely described in a new brochure, write for your copy.

FORMSPRAG COMPANY
23597 Hoover Road, Dept. 103
Warren (Detroit), Michigan

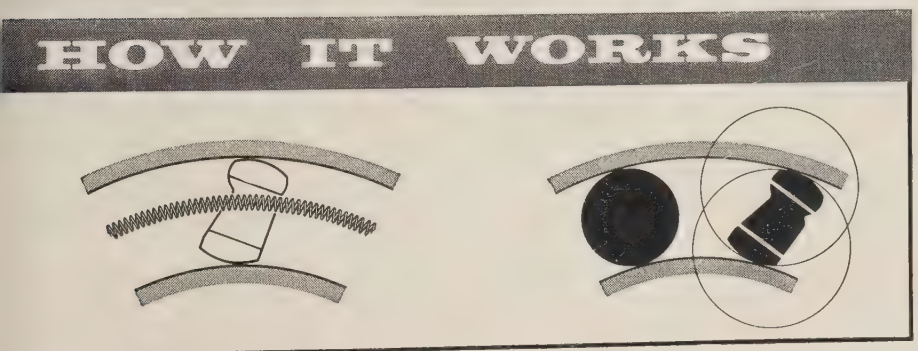
In Canada: Renold Chains Canada, Ltd.
In United Kingdom: Renold Chains Limited
Distributors in Principal Cities.



FORMSPRAG
CLUTCHES

World's Largest Exclusive Manufacturer of Over-running Clutches

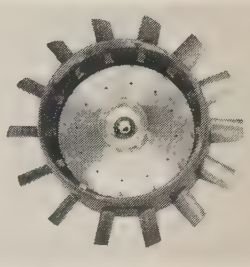
HOW IT WORKS



An expanding coil spring keeps the sprags in light contact with both inner and outer races. There is thus no lost motion, the driving torque being instantaneously transmitted between races. The Formsprag Clutch is so designed that it will transmit a greater torque in relation to its size and weight, than any other comparable type of clutch . . . specify Formsprag on over-running, back-stopping and indexing applications.

Forcing a ball or roller into a curved, wedged space is an old over-running clutch principle. The sprag is, in effect, a "roller" of increased diameter with greater contact surface in a given annular space. Formsprag Clutches engage at constantly changing contact points. Clutch life is prolonged and backlash eliminated. Also, with the inclined surfaces discarded, more sprags can be inserted to increase torque capacity.

RAWSON FOR NO-LOAD STARTS



The compactness, reliability and maximum capacity of Rawson Clutches have proven especially effective in aircraft applications such as helicopter transmissions. Used in a wide variety of other applications, Rawson Clutches eliminate costly reduced voltage starting equipment, permit use of lower cost smaller motors and provide full overload protection. Write for your copy of Rawson Clutch Catalog.

Write in No. 164 on Reader Service Card at start of Product Preview Section

priceless

When your priceless test data are recorded on film, you will find no more reliable source of film processing than CFI. At CFI all of your film requirements... for sales, training, and visual aids, 16 or 35mm, will receive the most careful attention.

CFI UNDERSTANDS your film problems. CFI has processed the invaluable film records of many vital projects. CFI recognizes the need for uncompromising quality and fast action.

CFI FACILITIES are complete... and modern. CFI has developed many new processes and is the leader in its field. CFI has complete security clearance, assuring safe handling of highly classified material.

CFI EXPERIENCE includes 40 years as the nation's largest and most progressive organization, with complete lab facilities in both Hollywood and New York.

FOR COMPLETE INFORMATION on capabilities and service available, write or call for a sales representative.

cfi

CONSOLIDATED FILM INDUSTRIES
959 Seward St., Hollywood 38, Calif. • HO 9-1441
521 West 57th St., New York 19, N.Y. • CI 6-0210

Write in No. 165 on Reader Service Card

STROBOSCOPE has highlight output

Model 121, stroboscope consists of a heavy duty power supply and a small 2-16 lamp assembly, which may be either hand-held or tripod-mounted. Features include a high and flicker-free light output of 10 candle-sec per flash up to 100 flashes per second, broad illumination angle of 0 deg, and a replaceable low cost flash tube with a life of over 36 million flashes, says **Chadwick-Helmuth Co., Dept. S/A, 472 E. Duarte Rd., Monrovia, Calif.**

The "Strobex" is especially suited for slow-motion viewing and photography from 5 cps to 10 kcps.

Write in No. 277 on Reader Service Card

MOTOR-PUMP PACKAGE for missile coolants

This miniaturized hydraulic vane pump-electric motor package is for low pressure circulation of coolant-oil around the high output tubes of missile electronic gear. Among applications for this line may be: missile skin cooling, electronic chasis cooling, fuel and lubricating pumps, small radar and computer drives, remote power supply. Dry weight is about 5.3 lbs and it occupies about 100 cu in. of space, says **Vickers, Inc., Dept. S/A, Detroit 32, Mich.**

Motor-pump performance includes an output range of 0.6 to 1.5 gpm at 11,300 rpm and 1000 psi.

Write in No. 278 on Reader Service Card

VARIABLE DRIVE is miniature

A 1¾-lb variable speed drive with a frequency response three times that of an electrical system and equal to that of a hydraulic system, needs only two in.-oz on the control shaft to go from full forward to full reverse in 0.05 sec, says **Humphrey, Inc., Dept. S/A, 3794 Rosecrans St., San Diego 10, Calif.** The miniature Servotran is suggested for actuators, recorders, and airborne instrumentation.

Output torque is constant and efficiency is between 85 and 95 per cent. Manual and electrical remote control provisions are available. The device is 3¾-in. long and two inches in diameter.

Write in No. 279 on Reader Service Card

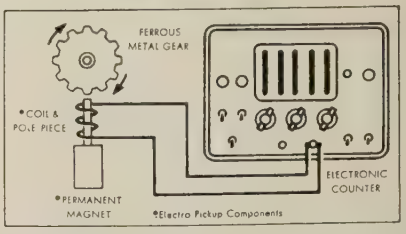
more on page 230

Engineering Ideas

Magnetic Transducers

A precise way to

SOLVE SPEED MEASUREMENT PROBLEMS



PROBLEM:

to measure turbine speeds up to 100,000 rpm

SOLUTION:

a Locate magnetic pickup adjacent to the teeth of any convenient gear used in the machine—or add a small bit of magnetic material to a non-magnetic rotor.

b Feed output of magnetic pickup directly to electronic counter. Set counter to count for a suitable time—such as 1 second (1/60 minute).

$$\text{RPM} = \frac{\text{Displayed count}}{\text{No. of teeth X counting time (in minutes)}}$$

Accuracy depends on three factors:

1. Accuracy of counter (usually ± 1 digit).
2. Length of counting time.
3. Number of pulses per revolution.

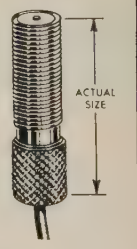
Example: 60-tooth gear providing 60 pulses/revolution with a count of 1 sec. (1/60 min.) produces an accuracy of ± 1 rpm at any speed. (Counter reads rpm directly with this set-up.) If counting time is increased to 10 sec., accuracy is ± 1/10 rpm.

ELECTRO PRODUCTS LABORATORIES

4501-C Ravenswood, Chicago 40, Ill.

Canada: Atlas Radio Ltd., Toronto

Sub-Miniature 3055



Use to Actuate, Provide telemetering data, Indicate, Control, Synchronize...

Electronic counters
Relays
Missiles
Motion
Speed
Vibration
Torque
Electric devices
Mechanical operations
Others

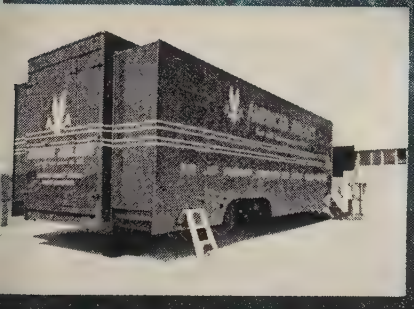
Electro ELECTRONIC EQUIPMENT

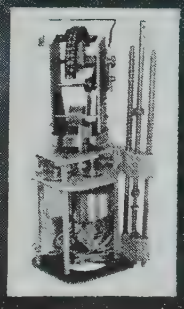
9420

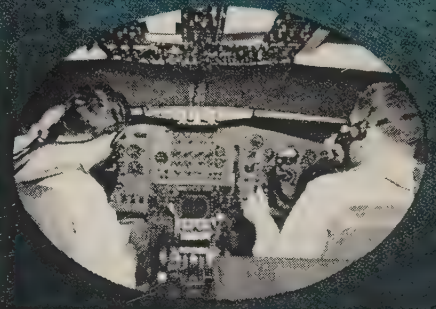
Write in No. 151 on Reader Service Card
Write in No. 166 on Reader Service Card

MIDWAY

SIMULATOR INSTRUMENTS







TRAINING JET CREWS QUICKER...

FOR AMERICAN AIRLINES 707's. Midway Flight Simulator nstruments are helping to accelerate jet crew training for American Airlines by reducing actual in-the-air time as much s 30%. Housed in a roadable trailer for transportation to any irline training area in the country, the flight simulator also rovides dramatic cost saving. Operation of the simulator costs nly $200. per hour compared with several times that amount or operation of the Boeing 707.

Reliability is important in Simulator Instruments too. For mulator "down time" could play havoc with training schedules nd drastically affect training budgets.

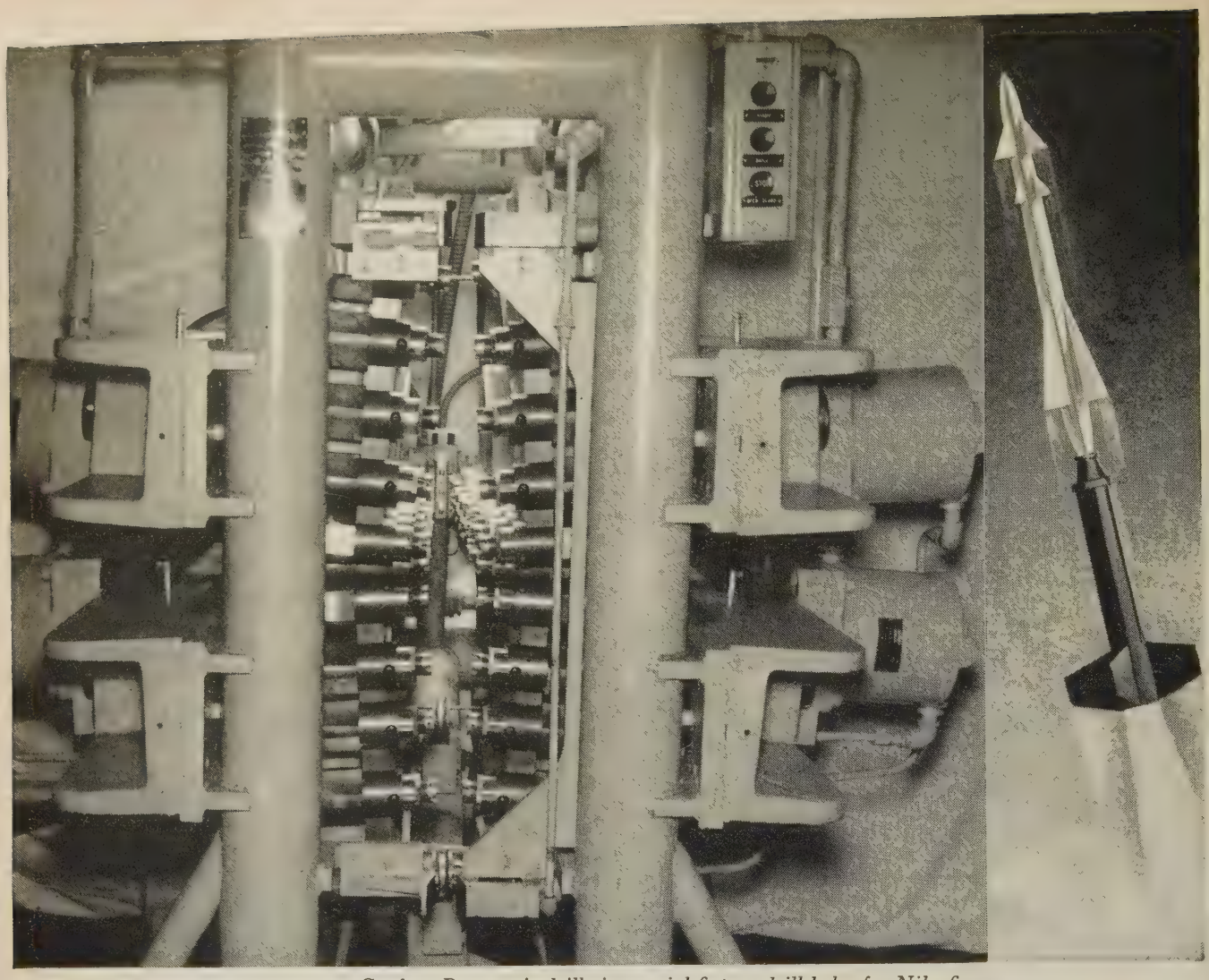
With the high degree of automated electronic jet flight today it is all the more important that the simulator is the place where the new jet pilot learns to respect . . . and live by . . . his instruments.

Midway has designed and produced hundreds of different types of simulator instruments which are helping to train new pilots for the Boeing 707, Convair 880, DC-8, and Lockheed Electra. Its modern air-conditioned plant, engineers and craftsmen are capable of producing instruments of many types to your particular design and quantity needs . . . from a single prototype unit to a full production run.

MIDWAY AIRCRAFT INSTRUMENT CORPORATION

185 BERGER STREET • WOOD-RIDGE • NEW JERSEY

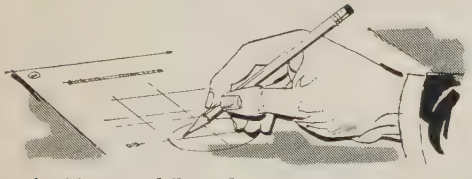
MIDWAY



Gardner-Denver air drills in special fixture drill holes for Nike fins.

Single air tool setup drills and countersinks 108 holes in 2 minutes

A PATTERN OF MULTIPLYING PRODUCTIVITY



A 100-year philosophy of growth—*there's no substitute for men*—has been confirmed again and again by Gardner-Denver air tool specialists. Their assistance in planning multiple screw driving, nut setting, and drilling setups has helped men in industry everywhere multiply productivity and cut costs.

One phase of fin fabrication for Nike missiles calls for drilling and countersinking 108 holes to exacting depths. Gardner-Denver air drills in this special fixture do the job in two minutes—automatically—at the touch of a button.

Multiple drilling problems, complex or simple, are easily solved with flexible Gardner-Denver air tools. Number of holes, different hole sizes, angles or drilling depths present no problem. A specially designed fixture with proper components from the Gardner-Denver air tool line can be engineered to fill every practical need.

Gardner-Denver can design and build you a complete special machine or we can work with your engineers to develop a fixture for your needs . . . help you select air tool components to meet exacting requirements. Get in touch with your Gardner-Denver air tool specialist soon.

GARDNER-DENVER Since 1859

1959

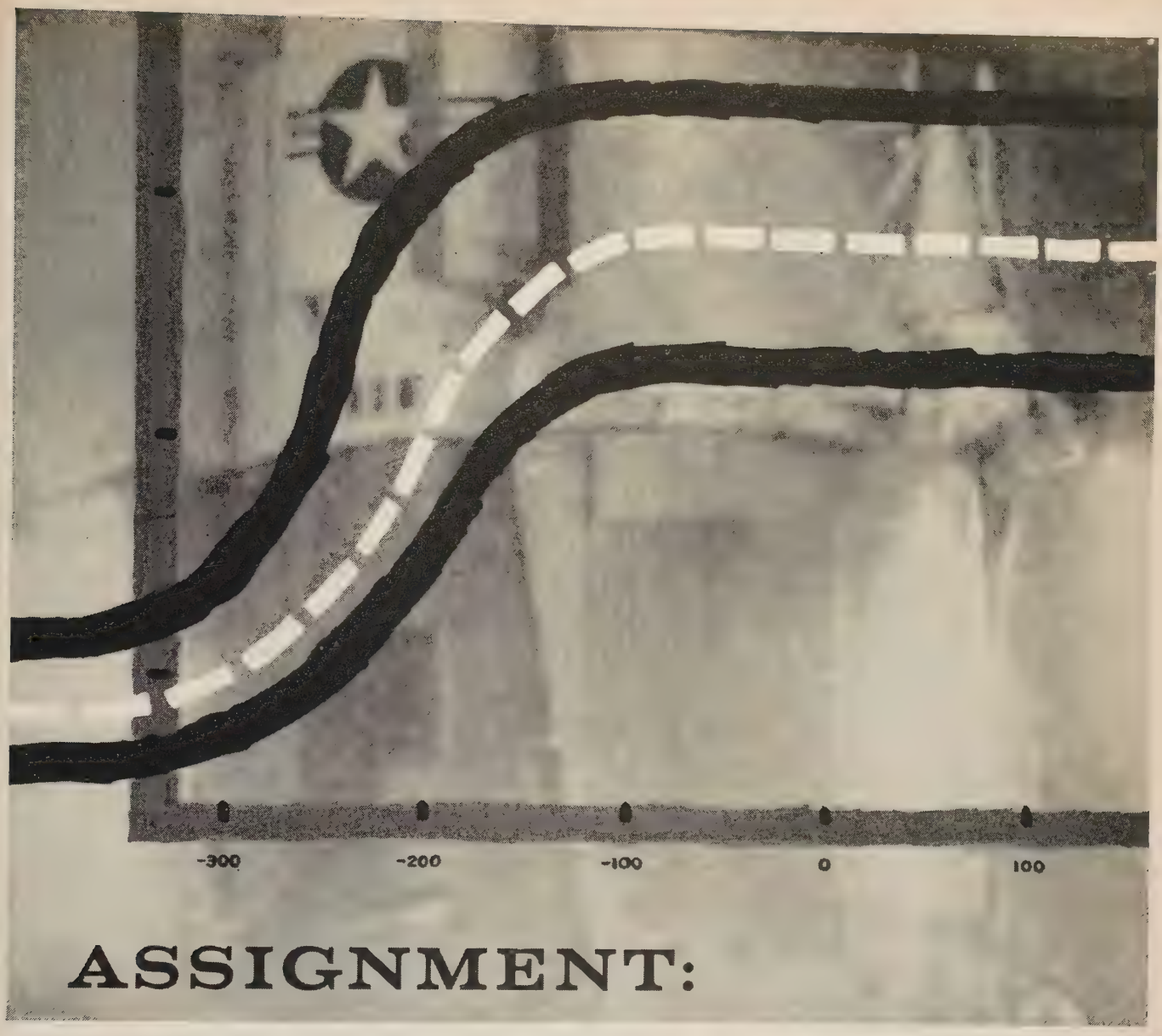
EQUIPMENT TODAY FOR THE CHALLENGE OF TOMORROW

GARDNER-DENVER

Gardner-Denver Company, Quincy, Illinois

In Canada: Gardner-Denver Company (Canada), Ltd., 14 Curity Avenue, Toronto 16, Ontario

Write in No. 167 on Reader Service Card at start of Product Preview Section



ASSIGNMENT:

CRYOGENICS

How Lukens *Application Research* helps you find the right steel plate for the job

If your assignment is designing equipment for extreme low temperature service—our Application Engineering staff can help you. They research problems of every description from the design stage right through to how the equipment has performed for years after its installation.

Missile components and liquefied gas tanks would be dangerously susceptible to cracking if made from ordinary steel. Seeking economical metals for such applications, Lukens engineers began years ago to watch the performance of nickel bearing alloys in a variety of low temperature equipment. Result: a broad understanding of metal behavior at various low temperature levels.

Examples: In the storage of liquefied oxygen, a tank of *Nine Nickel steel* provided more than eight years of trouble-free performance. Suitable to minus 320°F. service the steel showed no signs of cracking when removed for inspection. In frigid chambers for testing high altitude aircraft, *2½ percent nickel steel* is standing up well under pressures as high as 7,000,000 pounds. And in arctic locomotives operating at temperatures to minus 50°F. on rugged mountain roadbeds, main structures of *Lukens "T-1" Steel* have required no maintenance whatsoever.

Lukens Application Engineers know these cases . . . plus many more. *If your assignment is cryogenics, why not let it be our assignment, too?* Contact Manager, Application Engineering, K79 Services Building, Lukens Steel Company, Coatesville, Pa.

Helping Industry Choose Steels That Fit The Job

LUKENS ®

ASK FOR LUKENS NINE NICKEL STEEL BULLETIN

Write in No. 168 on Reader Service Card at start of Product Preview Section

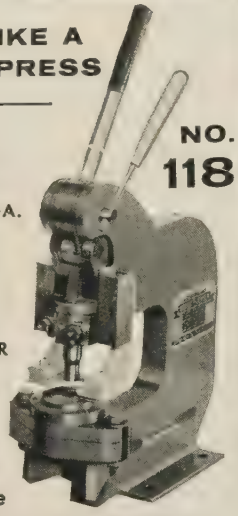
A LITTLE PUNCH
WITH **BIG** IDEAS

WHITNEY-JENSEN
HAND METAL PUNCH
(BENCH OR FLOOR MODEL)

BUILT LIKE A PUNCH PRESS

CAPACITY MILD STEEL
2" THRU 14 GA.
¼" THRU 3/16"

NO. 118



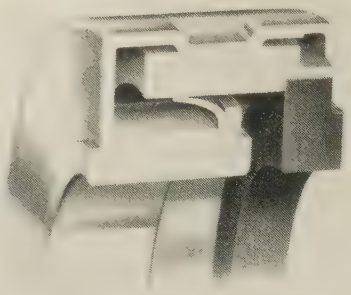
WILL TAKE MANY OF OUR SPECIAL PUNCH AND DIE SETS

Write for Literature

WHITNEY METAL TOOL CO.
710 Forbes St., Rockford, Ill. Since 1910

Write in No. 169 on Reader Service Card

METAL SHAFT SEAL bars internal fatigue

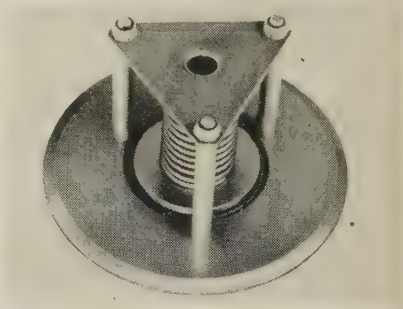


This all-metal shaft seal functions at temperatures ranging from −65° to +850° F. All components, except the face, are made of various high-temperature alloy steels. Face materials are carbon graphite or exotic alloys, says **Gits Bros. Mfg. Co., Dept. S/A, 1866 S. Kilbourn Ave., Chicago 23, Ill.**

Construction of the Met-L-Seal permits no internal fatigue and, it is claimed, "guarantees" against sudden complete operational failure in extreme conditions. Hydraulic balance produces optimum sealing under static and dynamic conditions.

Write in No. 282 on Reader Service Card

RELIEF VALVE handles high air volumes



Actuation at relatively low cracking pressure and the ability to handle a high flow volume of air are features in a pressure relief valve ideal for passenger planes and low pressure tank systems, says **Aero Supply Mfg. Co., Inc., Dept. S/A, Corry, Pa.** Cracking pressure is ten psig, and flow rate is 70 lb/min at a 12 psig differential.

The ambient or air flow operating temperature range is −65 to +400 deg F. The valve weighs 0.9 lb for a 2½-in. flow passage, and the valve can be modified for operating temperatures to 1000 deg F.

Write in No. 283 on Reader Service Card

more on page 235

1,000,000
A MILLION
Check Valves are proving
CIRCLE SEAL *superiority*

Today, with the experience gained in manufacturing over one million application-engineered Circle Seal check valves, James, Pond and Clark, Inc. is unique in its ability to meet the newest, most critical check valve requirements.

Rugged, high quality Circle Seal valves are a product of the valve industry's highest standards of quality. At James, Pond and Clark, Inc., check valves are *individually* inspected and tested against the most critical specifications. They insure continuous trouble-free operation under the toughest operating conditions posed by tomorrow-minded engineers.

From their own experience, specifying engineers know Circle Seal valves eliminate all reason for experimenting with less assured quality.

CIRCLE SEAL
precision valves

Please write today for free engineering data.

JAMES, POND & CLARK, Inc.
2181 EAST FOOTHILL BOULEVARD, PASADENA, CALIFORNIA

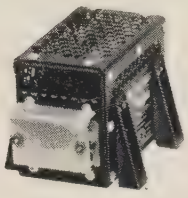
Write in No. 170 on Reader Service Card at start of Product Preview Section

ITT

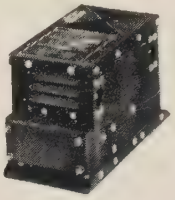
IN CUSTOM POWER EQUIPMENT

The Industrial Products Division of ITT offers a complete facility for custom airborne, ground, and ground-support power equipment and systems. Backed by the research, development, manufacturing, and technical experience of the worldwide International Telephone and Telegraph Corporation, we can package power equipment with built-in reliability to your exact requirements. Our complete engineering staff and environmental testing facilities enable us to supply reliable, high-quality units and systems, both quickly and at reasonable cost –

- DC Transformers
- T/R units
- Partial Systems
- Complete Systems
- High-voltage Supplies
- Inverters
- Magnetic Amplifiers
- Transistor-regulated Supplies



20-Amp Silicon T/R used on Chance-Vought F-8-U and Douglas A4D-2N.



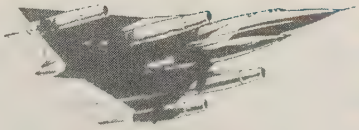
Launcher power supply for Lockheed's F-104 Starfighter

Static power unit for this nation's most advanced jet bomber.

Typical ITT Power Units. More than 50 different models of ITT power equipment are proving themselves in use every day.

THE LATEST IN STATIC POWER DESIGN

We have a complete line of fully qualified static power equipment, from 20 to 200 amps, in silicon or selenium. No moving parts. Long life – models up to 10,000 hours.



ITT provides power source for Convair's B-58 Hustler — a completely integrated electrical power system

Let us know your requirements . . . write, wire, or phone.

Industrial Products Division
INTERNATIONAL TELEPHONE & TELEGRAPH CORPORATION
15191 Bledsoe St. • San Fernando, Calif.

REGIONAL OFFICES: NEW YORK (Lodi, N.J.), PRescott 3-1550; DALLAS, FLeetwood 1-4468
CHICAGO, LOng Beach 1-3936; LOS ANGELES (San Fernando), EMpire 7-6161

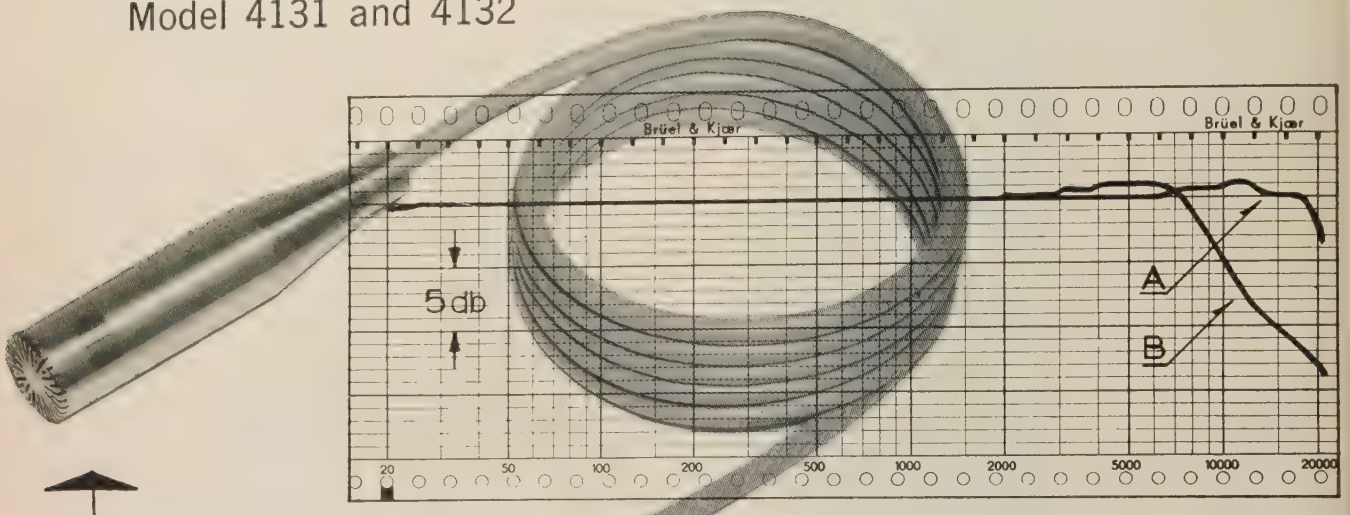
Write in No. 171 on Reader Service Card at start of Product Preview Section

Bruel & Kjaer Introduces:

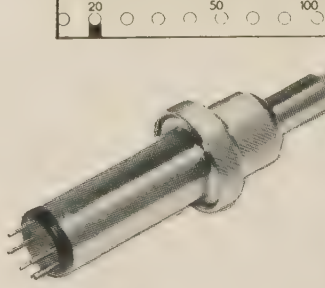
A NEW STANDARD

for measurement microphone performance

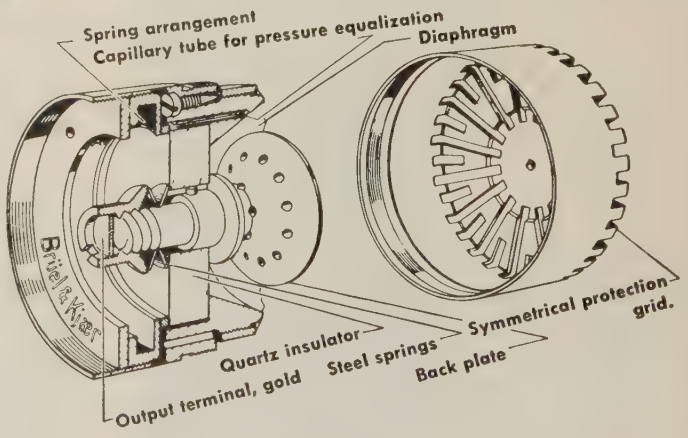
THE CONDENSER MICROPHONES
Model 4131 and 4132



A. Typical Flat Free-Field Response for Model 4131
B. Typical Flat Pressure Response for Model 4132



Sectional view of Microphone Cartridge ▶
(shown 1.35 times actual size)



★ **Interchangeable with ASA Standard Microphone**
★ **Greater Environmental Reliability**
★ **Applications Simplified with Integrated Supporting Equipment**
★ **Attractively Priced — Reasonable Deliveries**

Exclusive Franchised U. S. Marketing Agent for Bruel & Kjaer Instruments

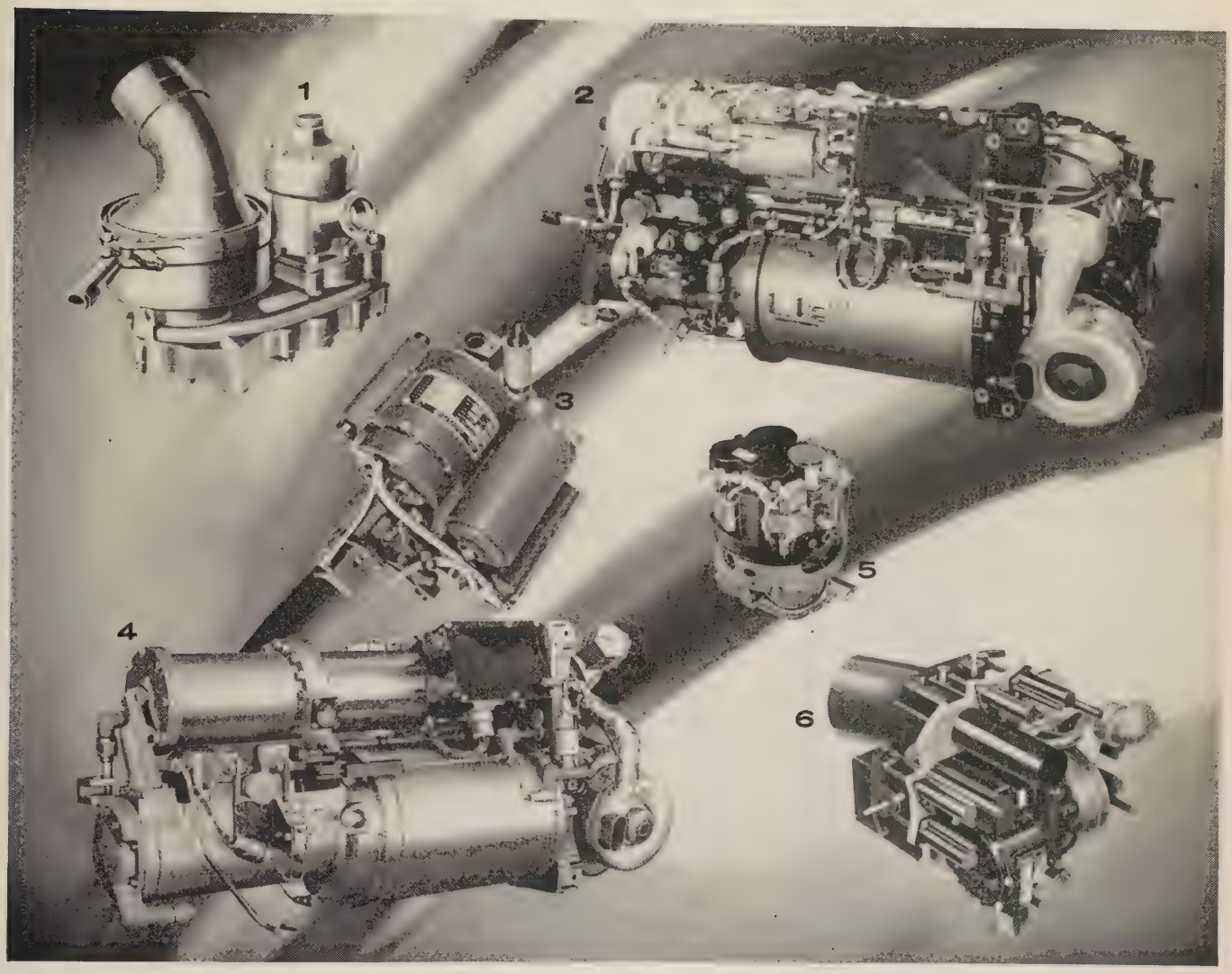
Gentlemen:
Please send me
☐ B & K Microphone Brochure
☐ B & K Complete Line Catalog

NAME_____
COMPANY_____
ADDRESS_____
CITY_____ ZONE___ STATE_____

B & K INSTRUMENTS, Inc.
3040 W. 106th STREET • CLEVELAND 11, OHIO • CLearwater 1-8430

Write in No. 172 on Reader Service Card at start of Product Preview Section

DELIVERED—thousands of missile APUs



1. *Solid propellant—hydraulic output* **2.** *Liquid propellant—hydraulic and electric output* **3.** *Solid propellant—electric and mechanical drive output*
4. *Liquid propellant—hydraulic and electric output* **5.** *Solid propellant—hydraulic and electric output*
6. *Solid propellant—hydraulic, electric and steering outputs*

AiResearch has designed, developed, manufactured and delivered thousands of missile accessory power units. Extremely reliable and lightweight, these various solid and liquid monopropellant APUs are completely self-sustaining within the missile system. Designed to minimum space and weight requirements, they are built to withstand high G loading and severe temperature extremes.

The several units pictured above provide hydraulic, electrical and/or steering surface control depending on the customer's requirement. Delivered horsepower ranges from 1.2 to 35 h.p. over hot gas operating durations from 30 seconds to 20 minutes. Electrical regulation is maintained as closely as ±½%. A significant advance in missile APUs is unit #6 pictured above. This package represents the first integrated hydraulic and electrical power unit providing a steering surface actuation system.

These tailored systems utilize the extensive hardware experience and complete laboratory, test and production facilities of AiResearch needed for quick and efficient quantity production of complex APU systems. AiResearch is the world's largest and most experienced manufacturer of lightweight turbomachinery—the key component of its APU systems. Your inquiries are invited.

THE GARRETT CORPORATION

AiResearch Manufacturing Divisions

Los Angeles 45, California • Phoenix, Arizona

Systems, Packages and Components for: AIRCRAFT, MISSILE, ELECTRONIC, NUCLEAR AND INDUSTRIAL APPLICATIONS

Write in No. 173 on Reader Service Card at start of Product Preview Section

FIELD TEST ENGINEERS

Versatile, practical-minded engineers with a record of accomplishment in the missile or aircraft business may qualify for a field test position at Convair-Astronautics — creators and testers of the mighty **ATLAS ICBM.** A number of positions must be filled immediately at various locations, from Cape Canaveral, Florida, to Vandenberg AFB near Santa Maria, California. "Astro's" field test operations are in two major groups: *Activation* — coordination of construction and the integration of support systems with facilities; and *Operations*—the preparation, checkout and launching of the missile itself.

Most important requirement for these positions is *versatility* — that blending of education and experience which equips engineers to think in terms of hardware under field test conditions. An engineering degree and missile test experience are most desirable, but a sound background in related work can furnish the necessary qualifications. Specific requirements are in **ELECTRONICS** (R.F. communications, instrumentation, missile control and guidance systems) **MECHANICAL ENGINEERING** (pneumatics, hydraulics, propellant handling and loading, mechanical ground support equipment), and **CIVIL ENGINEERING** (establishment of design criteria on missile facilities). There are also outstanding opportunities for **ENGINEERS AND SCIENTISTS** in many other areas and at all levels for a variety of space programs under way at Convair-Astronautics' San Diego headquarters. Our engineering representatives will be conducting **INTERVIEWS** in these and other cities soon:

ALBUQUERQUE, BALTIMORE, BOSTON, BUFFALO, CHICAGO, CLEVELAND, DAYTON, DENVER, DETROIT, EL PASO, FT. WAYNE, INDIANAPOLIS, KANSAS CITY, LOS ANGELES, MINNEAPOLIS, NEW ORLEANS, NEW YORK, PHILADELPHIA, PITTSBURGH, ST. LOUIS, SPRINGFIELD, MASSACHUSETTS, AND WASHINGTON, D.C.

We invite qualified engineers and scientists to send a detailed resume at once so advanced arrangements can be made for a confidential interview. Write to Mr. G. N. McMillan, Engineering Personnel Administrator, Department 130-90.

CONVAIR/ASTRONAUTICS
CONVAIR DIVISION OF
GENERAL DYNAMICS
5501 KEARNY VILLA ROAD, SAN DIEGO, CALIFORNIA

Check Employment Inquiry Form on Page 157

TRANSVERTERS are efficient

The efficient static dc-to-ac transverters in this line feature high power-to-weight ratio, arc-free operation, and long service life, says **Freed Transformer Co., Inc., Dept. S/A, 1704 Weirfield St., Brooklyn 27, N. Y.** Hermetically-sealed porcelain terminals have been used in the three models available.

Models MAC-12-20-1 and Mac-12-30-2, both 12-V dc input types, have maximum outputs of 170 and 250 W, respectively. The MAC-6-30-1, a six-V dc input unit, has an output of 150 W, maximum. All three have an output voltage of 115 V, 60 cycles, which varies directly with input voltage.

Write in No. 284 on Reader Service Card

FASTENERS are self-sealing

A self-lubricating Teflon shim set in an O-ring groove in the head of a cold-headed stress fastener makes the fastener a self-sealing device, says **Aero-Stat Co., Dept. S/A, 8021 S. Western Ave., Los Angeles 47, Calif.** Tests indicate that the sTa-seal fasteners have excellent resistance to most known destructive chemicals, fuels, hydraulic fluids, and synthetic lubricants, over a wide range of temperature variances.

The fasteners may be reused without loss of sealing properties and can be installed with standard tools.

Write in No. 285 on Reader Service Card

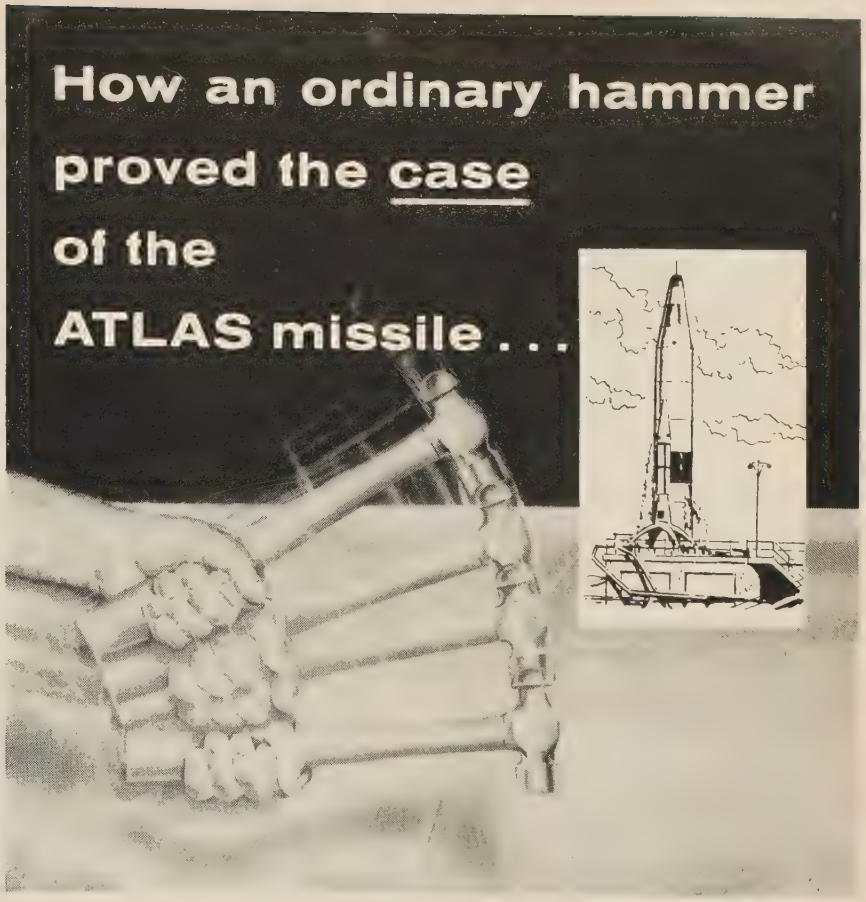
DRILL BUSHING cuts friction heat

The Ceram-A-Grip drill bushing, a device for plastic tooling, has a thin shell of ceramic material fused to its outer surface. The shell creates a superior heat barrier that effectively insulates the plastic potting material from any excess frictional heat build-up in the bushing, says **American Drill Bushing Co., Dept. S/A, 5107 Pacific Blvd., Los Angeles 58, Calif.**

The new bushing is reported to give maximum protection against bushing misalignment and spin-out resulting from softening, through frictional heat, of the plastic bonding material.

Write in No. 286 on Reader Service Card

more on next page



The body of the missile, essentially one big fuel tank, is similar in principle to an inflated football. Convair-Astronautics broke new ground in missile design by developing a super-strong structure with a comparatively thin stainless steel skin to keep weight to a minimum. This stainless steel skin is so thin that the interior has to be pressurized to preserve the shape of the body as propellants are consumed in flight, or when the missile is being transported on the ground.

Some critics, however, thought the body was too fragile—"You could dent it with a hammer." So, recently, when the Scientific Advisory Board, engaged in a re-evaluation of all missile programs, arrived at Convair-Astronautics to take a reading on the ATLAS, they found that Convair had thoughtfully placed a number of hammers within easy reach of a finished missile. "Go ahead, bash it," invited Convair. The SAB members swung lustily. *Not a dent was registered,* for, although the walls are thin, the stainless has a minimum tensile strength of 200,000 psi.

This stainless steel skin material, supplied by Washington Steel, required extremely close control of mechanical properties and gauge tolerance which are regularly produced through Washington Steel's long experience with precision rolling equipment.

Stainless Steel—the Space Age Metal

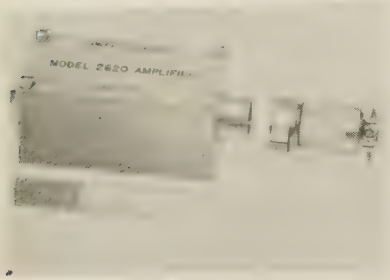
Washington Steel Corporation

7-V Woodland Avenue

Washington, Pa.

Write in No. 174 on Reader Service Card at start of Product Preview Section

CHARGE AMPLIFIER is completely transistorized



Model 2620 transistor amplifier amplifies and converts charge to voltage, eliminating the high input impedance usually necessary for low-frequency response. The transducer and amplifier may be placed up to 300 ft apart with no signal loss or need for cathode follower, and additional capacitance causes no attenuation of charge signal, says **Endevco Corp., Dept. S/A, 161 E. California St., Pasadena, Calif.**

Two continuously variable gain ranges are provided, both based on a 500-uuf unit source—a low range from 0.8 to 12 and a high range from 4 to 15. Temperature range is —65 F to +185 deg F. The unit measures 1 by 2¼ by 1 in. and weighs 4½ oz.

Write in No. 287 on Reader Service Card

STRAIN GAGE PLOTTERS record at high speeds

Structural and engine load tests can be rapidly plotted by means of the high speed strain gage plotters Models 220 and 221, says **Gilmore Industries, Inc., Dept. S/A, 13015 Woodland Ave., Cleveland 20, O.** The devices can scan and record up to 20 channels per minute and plot up to 96 channels.

Features include three zero positions per channel, separate range selectors, and separate gage factor selectors.

Write in No. 288 on Reader Service Card

INSULATING VARNISH is fast-drying

Type 642-AF fungicidal insulating varnish is a clear, fast, air-drying insulating varnish which can be applied to the surface of instruments, transformers, printed circuits, ceramic resistors, insulators, and other electronic equipment subject to fungus attack in hot, humid climates, says **Schenectady Varnish Co., Inc., Dept. S/A, Schenectady, N.Y.**

The varnish is water-white, will not "after-yellow," and is ideal for application over stamped or painted identifying numbers.

Write in No. 289 on Reader Service Card

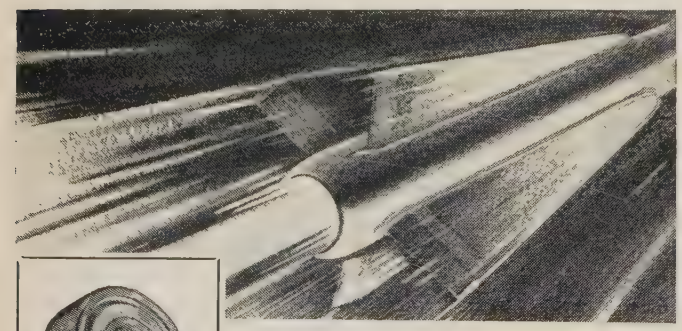
DUAL PRESSURE GAGE for two-system comparison

This dual-reading pressure gage provides instantaneous comparisons from two separate pressure systems and weighs less than ¼lb. Gages are available in pressure ranges from 0 to 70 psi and 0 to 20,000 psi, says **Glassco Instrument Co., Dept. S/A, Pasadena, Calif.**

The units use 2 concentric Bourdon helix sensing elements to read separate pressure inputs which are fed through a dual entry fitting at rear of gauge. Needles of both sensing elements read out on the same dial scale for instant comparisons. The needles are color coded and numbered.

Write in No. 290 on Reader Service Card

more on page 240



Minute Giants . . .

B.M.B. Miniature Bearings to the highest precision limits, are made specially for Space craft, missile or ground support instrumentation.

Stainless Steel for servo applications—B.M.B. have supplied miniature bearings to the American market for the past ten years.

Miniaturization plus reliability equals faultless functioning equals B.M.B. Miniature Bearings.

AGENTS:

David R. Grossman Co., 155 East 44th Street, New York 17, N. Y. U. S. A.

Engis Equipment Co., 431 South Dearborn Street, Chicago, Illinois, U. S. A.

Manufacturing Associates, 1416 Westwood Blvd., Los Angeles 24, California, U. S. A.

BRITISH MANUFACTURED BEARINGS CO., LTD.

Sole Selling Agents:

B.M.B. Sales Ltd., High Street, Crawley, Sussex, England.

Write in No. 175 on Reader Service Card

Sicon®

HEAT RESISTANT FINISH

PROTECTS ENGINE SHROUDS OF THE

MARTIN MATADOR

When USAF TM-61 Martin Matadors are recalled for servicing and refinishing, SICON Silicone finish is specified because it meets the performance required.

Sicon's ability to withstand high temperatures up to 1000°F. without breakdown has won an enviable name for itself in the aircraft industry, as well as in many others.

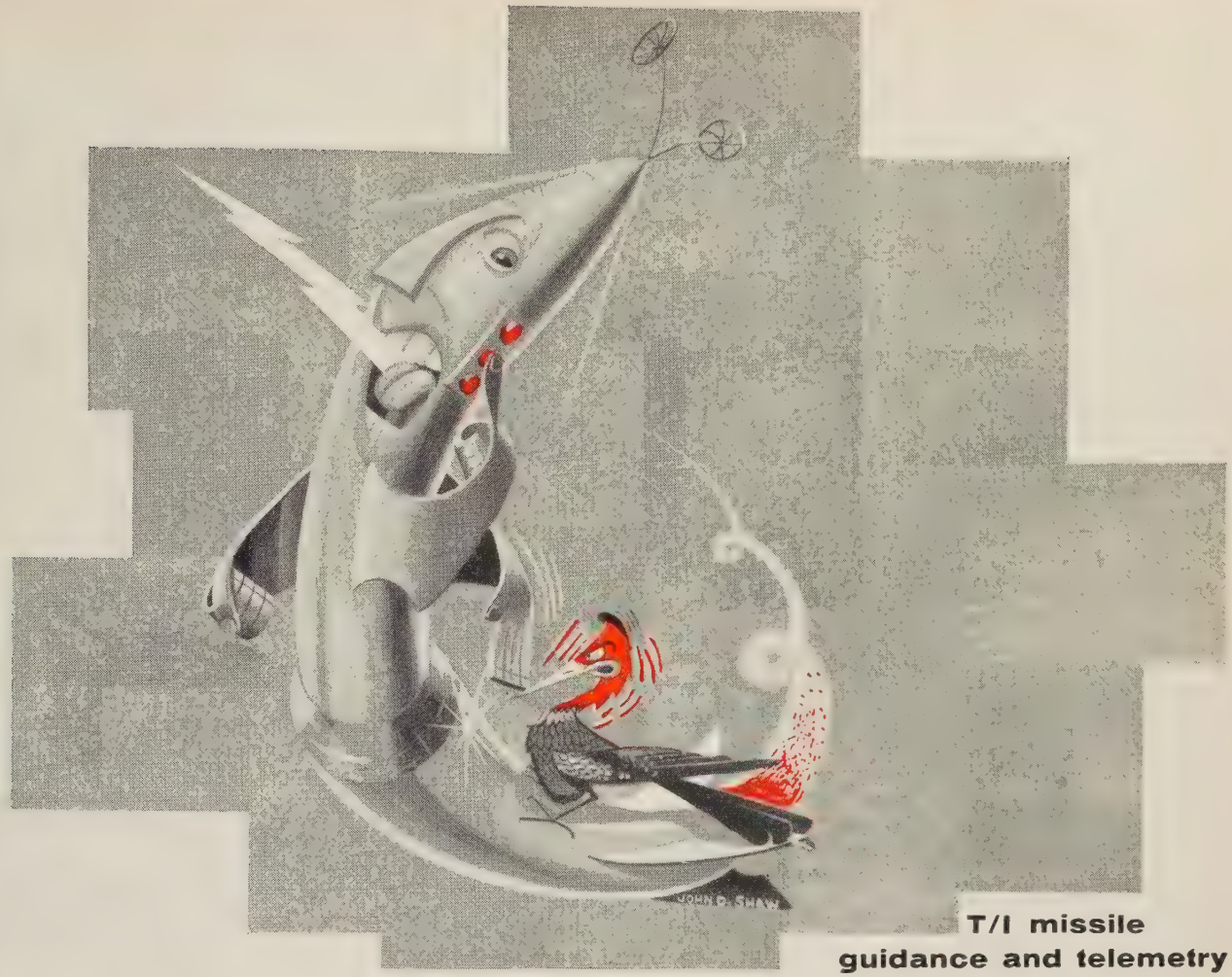
Write for new SICON Bulletin—Dept. No. G-33.

MIDLAND INDUSTRIAL FINISHES COMPANY

WAUKEGAN · ILLINOIS

ENAMELS • SYNTHETICS • LACQUERS • VARNISHES

Write in No. 176 on Reader Service Card



T/I missile
guidance and telemetry

BEEPS WITH A HIGH IQ

...for missile sensing, guiding and telemetering

Electronic signals that report the truth, the whole truth, and nothing but . . . wring the best performance from missile systems. By pushing beyond known capabilities in sensitivity and accuracy, Texas Instruments is producing "high IQ" systems and equipments for a dozen guided vehicles used in every basic mission: air-to-air, air-to-surface, surface-to-air, surface-to-surface — IRBM and ICBM—plus drone sensors and satellite instrumentation. TI exceeds tough specs against tight deadlines, regularly . . . specs asking solutions to problems never posed before. For detailed discussion, cleared personnel please write or call: SERVICE ENGINEERING DEPARTMENT.

RESEARCH/DESIGN/DEVELOPMENT/MANUFACTURING of systems for: *Air traffic control* • *Airborne early warning* • *Antimissile* • *Antisubmarine warfare* • *Attack control* • *Countermeasures* • *Missile systems Navigation* • *Reconnaissance* • *Space electronics; and on detector cells, engine instruments, infrared, intercom, microwave, optics, radar, sonar, telemetry, time standards, timers, transformers and other precision devices.*

APPARATUS DIVISION

TEXAS INSTRUMENTS
INCORPORATED
6000 LEMMON AVENUE
DALLAS 9, TEXAS

Write in No. 177 on Reader Service Card at start of Product Preview Section

Why the Atlas...has an 18-8 Stainless skin

This skin runs hot and cold. Cold because of liquid oxygen down at –297°F. And hot because of aerodynamic heating which may heat it to the 400 to 600°F range.

The problem was to get a material which is strong in thin gauges of sheet, yet keeps its strength, toughness and ductility at extremely low temperatures . . . as well as moderately elevated ones. Of course, it must resist oxidation and many atmospheric environments, too.

Designers at General Dynamics-Convair Division found that the 18-8 Austenitic Stainless Steels, which contain about 8% Nickel, have excellent low temperature properties and meet all of the other requirements as well. In addition, 18-8 Stainless Steels can be formed and welded readily.

Easily fabricated 18-8 Stainless Steels could be your answer to a sub-zero problem. If you'd like information on their low temperature properties, it's yours for the asking from Inco.

THE INTERNATIONAL NICKEL COMPANY, INC.

67 Wall Street INCO New York 5, N.Y.

INCO NICKEL

NICKEL MAKES ALLOYS PERFORM BETTER LONGER

ADD A "NEW DIMENSION" TO YOUR CAREER!

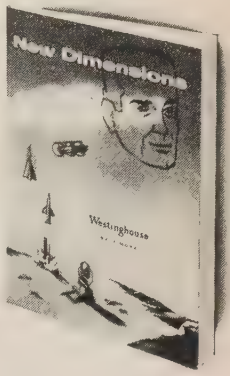
Your career advances by degrees . . . professional degrees. At Westinghouse-Baltimore, you can enjoy stimulating project activities . . . plus the opportunity to advance your career in the Westinghouse Graduate Study Program. In affiliation with The Johns Hopkins University, the University of Maryland, and other leading universities, qualified engineers are assisted in their work toward graduate degrees. This program is described in "New Dimensions" . . . the story of Westinghouse-Baltimore.

Current Career Openings Include:

- Solid-State Physics
- Microwave Systems and Components
- Radar Systems
- Network Synthesis
- Analogue and Digital Computer Design
- Ferret Reconnaissance
- Electronics Instructors
- Communications Circuitry
- Field Engineering
- Technical Writing
- Electronic Packaging
- Human Engineering

Write for "New Dimensions" . . . the informative brochure that takes you behind the scenes at Westinghouse-Baltimore today.

For a confidential interview, send a resume of your education and experience to: Mr. A. M. Johnston, Dept. 933, Westinghouse Electric Corporation, P. O. Box 746, Baltimore 3, Maryland.

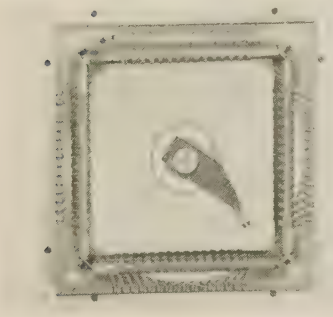


Westinghouse

BALTIMORE

Check Employment Inquiry Form on Page 157

VARIABLE DELAY LINES feature unique design



The unique, recently patented design of these variable delay lines has eliminated many components and solder connections found on normal units, says **Control Electronics Co., Inc., Dept. S/A, 10 Stepar Place, Huntington Station, N.Y.**

The switch pattern is printed on a thin dielectric material with copper on both sides. The switch segments act as capacitors which are trimmed by a circular cutter that removes the undesirable portion of the switch segments, as the delay is observed by an oscilloscope. The unit, through its inherent simplicity, is more economical, rugged, and accurate than its counterparts, it is claimed.

Write in No. 291 on Reader Service Card

RELIEF VALVES for hydraulic use

Aircraft and missile hydraulic relief valves designed to exceed Mil-V-8813 (ASG) specifications have been introduced by **PneuDraulics, Inc., Dept. S/A, Pomona, Calif.** Models 1000, 1100, and 1200, for ¼-, ⅜-, and ½-in. tube sizes, respectively, operate at system pressures to 4000 psi within —65 to +275 deg F.

Adjustable pressure ranges of 500 to 825, 825 to 1400, 1400 to 2300, and 2300 to 3850 psi are available.

Write in No. 292 on Reader Service Card

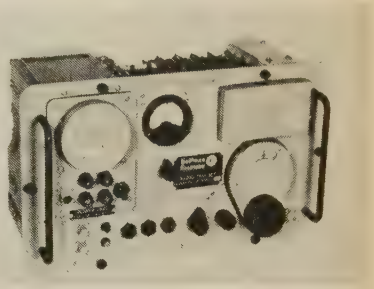
TOXICITY INDICATOR for hydrogen fluoride

Presence of hazardous amounts of hydrogen fluoride in air, 0.5 to 5 ppm or more, can be learned quickly with this toxicity measure (M-S-A Hydrogen Fluoride Detector) made by drawing air over a sensitized filter paper with an aspirator bulb, says **Mine Safety Appliances, Dept. S/A, 201 N. Braddock Ave., Pittsburgh 8, Pa.**

A pink color is compared with a color chart and the HF concentration is read on a calibration chart supplied with a lightweight, portable detector case.

Write in No. 293 on Reader Service Card

TACAN BEACON SIMULATOR is portable



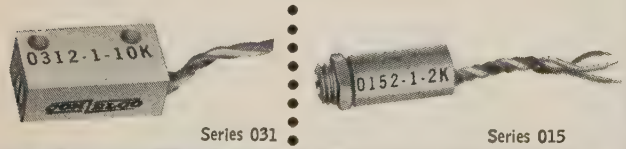
Model HL-119 simulates the operation of the Tacan ground beacon by generating a standard Tacan signal on any two of the 126 Tacan channels. The instrument allow checks of range and bearing operation, coding and decoding, and operating frequency, and in addition, measurements of peak power and receiver sensitivity of airborne equipment can easily be performed, says **Hoffman Electronics Corp., Hoffman Laboratories Div., Dept. S/A, 3740 S. Grand Ave., Los Angeles 7, Calif.**

Measuring 8¾ by 12 by 18½ in. and weighing about 35 lb, the instrument is suitable for use wherever Tacan or DMET equipment is used.

Write in No. 294 on Reader Service Card

more on page 244

Trimming **POTENTIOMETERS** *and Variable* **RESISTORS**



Series 031 Series 015

CON ELCO **PACKS MORE POWER... MORE RESISTANCE... MORE RELIABILITY... INTO LESS SPACE!**

. . . Compare CON ELCO potentiometers . . . you'll find these quality controlled, precision instruments exceed all trade demands of miniaturization, reliability, resolution, vibration, shock, acceleration, humidity . . . and extreme environmental operating conditions.

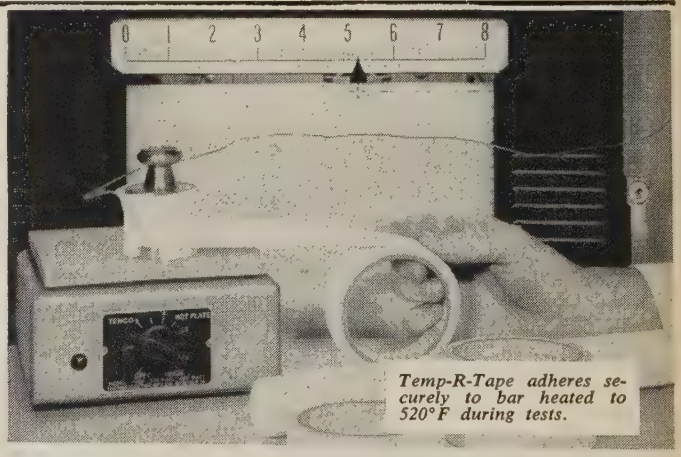
CON ELCO provides instruments to fit every design standard, offers more power per cu. in. Ratings available up to 2.75 watts, with operating temperature ranges as high as —55°C to +180°C. Standard resistances from 10 Ω to 125K Ω (Many higher resistances available).

Available immediately in seven different sizes and configurations for chassis, panel or printed circuit mounting. Insulated stranded wire leads, solder lugs or printed circuit pins simplify packaging.

Let CON ELCO engineers help you with any application problems. For complete CON ELCO story write today. . . .

CON ELCO
1711 S. Mountain Ave.
Monrovia, California

Write in No. 179 on Reader Service Card



Temp-R-Tape adheres securely to bar heated to 520°F during tests.

CHR PRESSURE-SENSITIVE TEFLON® TAPES

- *—100°F to 500°F applications*
- *Class H and Class C insulation*
- *Non-stick and low friction facing*
- *Chemical resistant facing*
- *Easy to apply*

Temp-R-Tape is available from stock in rolls and sheets. All four types — Temp-R-Tape T; TH; C and TGV — combine some form of Tefion backing with silicone polymer adhesive to provide easy-to-apply pressure-sensitive and thermal curing pressure-sensitive tapes for electrical and mechanical applications. Designed for extreme temperatures, Temp-R-Tapes possess high dielectric strength, low power factor, high elongation, negligible moisture absorption, are non-corrosive and non-contaminating.

FREE SAMPLES and folder — write, phone or use inquiry service.

Sold nationally through distributors

CHR **CONNECTICUT HARD RUBBER**

**duPont TM*

Main Office: New Haven 9, Connecticut

Write in No. 180 on Reader Service Card

Write in No. 181 on Reader Service Card ➡

PRIMARY PRESSURE STANDARD

ACCURACY ±1/50% OF READING (PSID)
RANGE 0.4 TO 250 PSID

- SIX DIGIT DISPLAY
- DIRECT READOUT IN PRESSURE
- PORTABLE OR RACK MOUNTED
- INTEGRAL PRESSURE CONTROL
- ONE DIAL COMPENSATION FOR LATITUDE AND ALTITUDE (SURVEYED)
- WILL ACCOMMODATE ABSOLUTE AND GAUGE PRESSURE WITH SIMILAR ACCURACY

Please discuss your requirements with our engineers

LEONARD PASADENA

Wallace O. Leonard, Inc.
373 SOUTH FAIR OAKS AVENUE
PASADENA, CALIFORNIA
TELEPHONE SYCAMORE 2-7131
TWX-PASA CAL 7321

PRECISION GYROS

A Proven Kearfott Capability. The increasing use of Kearfott gyros and gyro platforms in today's missile programs, underscores the company's leadership in gyro design and production. Such missile projects as the Atlas, Bomarc, Polaris, Snark, Subroc and Talos rely on Kearfott gyros or gyro platforms, as do the majority of manned aircraft now in service.

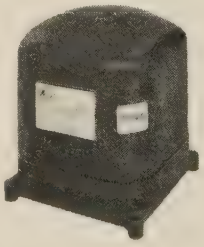
FLOATED RATE INTEGRATING GYROS. High accuracy miniature gyros specifically designed for missile use. The performance characteristics of these gyros are superior to any comparably-sized units available today. Hermetically sealed within a thermal jacket and ruggedly designed for adaptability to production methods. These gyros operate efficiently at unlimited altitudes. More precise performance characteristics can be provided in the same dimensions.

TYPICAL CHARACTERISTICS

Mass Unbalance:
Along Input Axis: 1.0°/hr maximum untrimmed
Standard Deviation (short term):
Azimuth Position: 0.05°/hr
Vertical Position: 0.03°/hr
Drift Rate Due to
Anisoelasticity: Steady Acceleration: .015°/hr./g² maximum
Vibratory Acceleration: .008°/hr./g² maximum

Damping:
Ratio of input angle to output angle is 0.2
Characteristic Time:
.0035 seconds or less.
Weight: 0.7 lbs.
Warm-up Time:
10 minutes from −60°F
Life:
1000 hours minimum

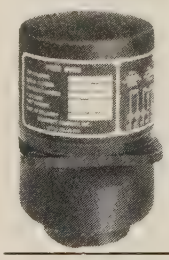
VERTICAL GYROS. Provide accurate vertical reference in the form of two 400 cps synchro signals proportional to the sine of gimbals' displacement about pitch and roll axes. Gravity-sensitive vertical reference device provides electrical signals directly to torque motors which maintain gyro spin axis perpendicular to earth's surface. Hermetically sealed, they are unaffected by sand, dust, sun, rain, salt spray, humidity or fungus conditions as specified in MIL-E-5272A.



TYPICAL CHARACTERISTICS

Repeatability to Established Vertical: To within a cone of half angle equal to 15 minutes of arc (± 8 minutes typical).
Free Drift Rate in 5 minutes Time: 2.5° maximum at room temperature. 3.75° at −54°C and + 71°C.
Erection Rate: 2.5°/Min.
Initial Erection: The gyro will erect to within ± 1° of established vertical in 60 seconds time after application of power at room temperature.
Vibration and Shock: The gyro will meet above characteristics after vibration of 0.060″ total excursion cycling between 10 CPS and 55 CPS for 4.5 hours. Shock test in accordance with MIL-E-5272A Procedure 2.
Operating Life: 1000 hours minimum.

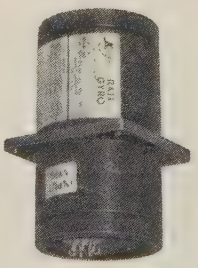
FREE GYROS. Provide extremely accurate reference in the form of electrical output signals proportional to displacements about outer axes. With 360° of freedom about outer axes (inner axis freedom depends on the unit involved), these gyros may be mounted to give output signals of either pitch, roll or yaw. Shock and vibration resistant, they are equipped with quick-starting motors for applications in high performance missiles and aircraft.



TYPICAL CHARACTERISTICS

Free Drift Rate: Within 0.5° in one minute time.
Shock: The gyro operates satisfactorily without damage after 60g shock of .015 seconds duration.
Hermetically Sealed: These instruments are hermetically sealed and are not affected by sand, dust, sunshine, rain, humidity or fungus conditions.
Operating Temperature Range: Gyros operate in ambient temperatures below −20°C to + 100°C. A maximum of 3 minutes of operation at 400°F will not damage these gyros nor impair their accuracy.
Weight: 5.5 lbs. approximately.

SPRING RESTRAINED RATE GYROS. Almost universally applicable in missile and aircraft designs demanding precise angular rate measurements in environments of extreme shock and vibration. Fluid filling provides added immunity to shock and vibration, reduces bearing friction in AC types and potentiometer wiper friction in DC types. Kearfott design advances permit 30 second warm-up, overcome fluid viscosity variations resulting from ambient temperature change. These gyros are single-degree-of-freedom, viscous damped, spring restrained, with gimbals supported by precision bearings. Compensatory damping mechanisms eliminate need for accessory heaters.

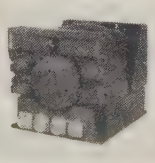


TYPICAL CHARACTERISTICS

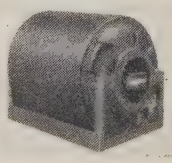
Maximum Rate (°/sec.):	45-1000
Natural Undamped Frequency (cps) (± 10%):	16
Damping Ratio (of critical) over Temperature Range:	.35 to .80
Operating Temperature Range (°F):	−65 to +185
Vibration:	12 g's @ 20-2,000 cps
Shock (Motor Running):	60 g's for 6.5 milliseconds
Warmup Time (Sec.):	30
Weight (lbs.) (max):	1.5
Gyro Time Constant (Sec.)	.012

Engineers: Kearfott offers challenging opportunities in advanced component and system development

Roll Stabilized Directional Gyro



3 Gyro–4 Gimbal Gyro Reference



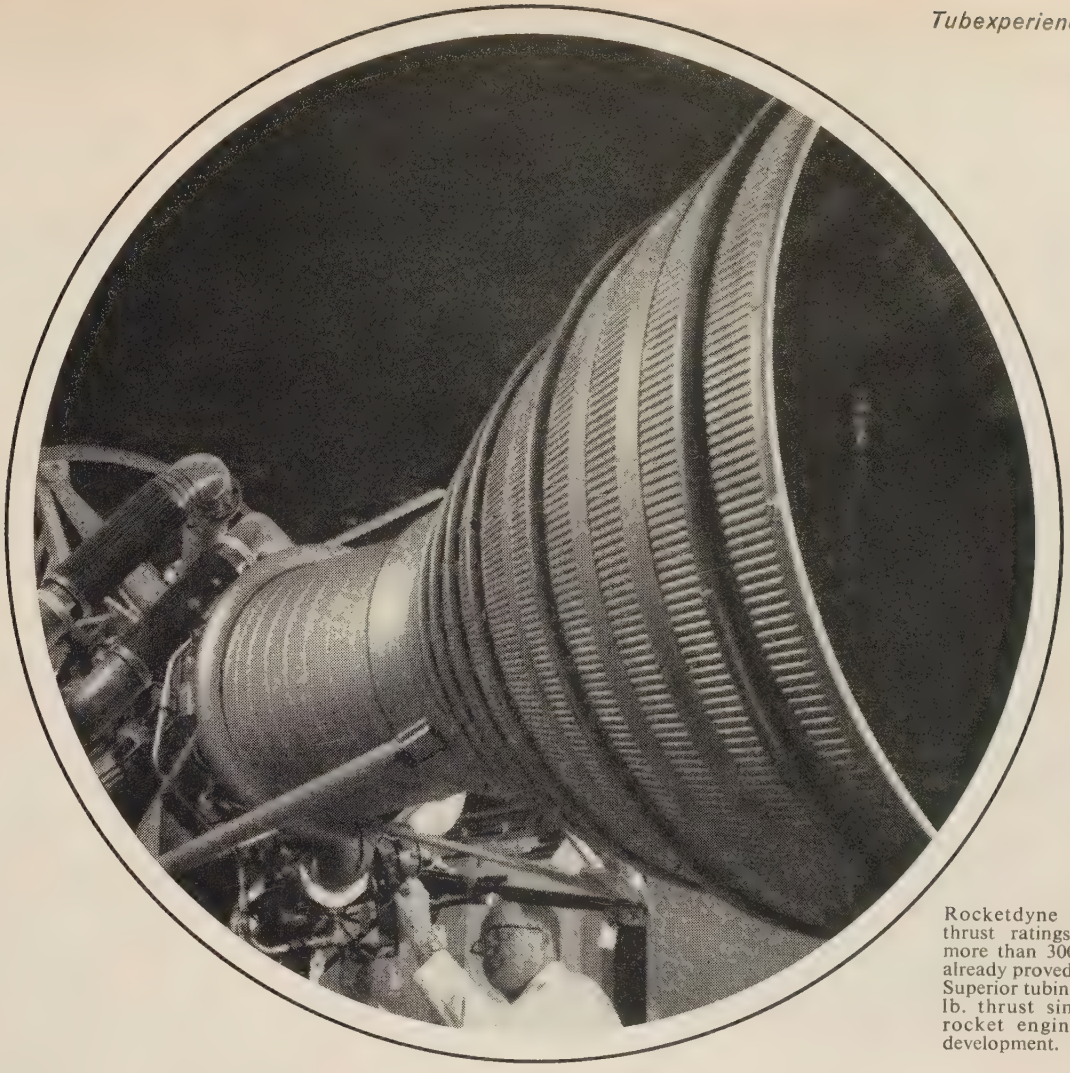
25 Pound Inertial Platform

Kearfott | A GENERAL PRECISION COMPANY

KEARFOTT COMPANY, INC., LITTLE FALLS, N. J.
A subsidiary of General Precision Equipment Corporation

Sales and Engineering Offices: 1500 Main Ave., Clifton, N. J
Midwest Office: 23 W. Calendar Ave., La Grange, Ill.
South Central Office: 6211 Denton Drive, Dallas, Texas
West Coast Office: 253 N. Vinedo Avenue, Pasadena, Calif.

Write in No. 182 on Reader Service Card at start of Product Preview Section



Rocketdyne engines with thrust ratings of 5000 to more than 300,000 lb. have already proved the quality of Superior tubing. A 1,500,000 lb. thrust single chamber rocket engine is now in development.

Superior Thin-Wall Nickel Tubing Survives Rigors of Preparation for Outer Space

Thrust chambers of the Rocketdyne engines that propel the Atlas, Thor and Jupiter missiles into outer space are composed of over 200 pieces of formed and shaped Superior Grade "A" nickel tubing. Tubing must meet rigid design requirements and be amenable to exacting and intricate forming and fabrication. Finished parts are subjected to tests that must insure reliability. Typical of the unusually severe fabrication, test and operational conditions it must survive are the following.

- Die-press operations which develop pressure of 600 psi in the press and up to 20,000 psi in the tube while forming cross-section shapes varying from round to rectangular to octagonal.

- Brazing operations which subject the tube to as many as 15 heating and cooling cycles at approximately 1200°F.

- Test firings far in excess of required tactical maximum in which the only material between the coolant in the tubes and the combustion gases (at approximately 5000°F and high pressures) is the very thin wall of tubing.

Only the highest quality tubing, produced and fabricated with master skills, is good enough for the thrust chambers in which Superior tubing serves. That is why Rocketdyne Division, North American Aviation, Inc., depends on Superior for much of its tubing needs.

Superior's experience in the nuclear and missile tubing field is extensive. More than 120 analyses in a wide range of ID, OD and wall thicknesses are now available. They are described in Bulletin 41. Write for a copy today. Superior Tube Company, 2038 Germantown Ave., Norristown, Pa.

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010 in. to ⅜ in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company, Los Angeles, California • FIRST STEEL TUBE MILL IN THE WEST.

Write in No. 183 on Reader Service Card at start of Product Preview Section

THE S. S. White Industrial Airbrasive Unit

We don't recommend slicing up the family's fine Limoge China, but this does illustrate the precisely controlled cutting action of the S. S. White Airbrasive Unit. Note how clean the edge is, and how the delicate ceramic decoration is unharmed.

The secret of the Airbrasive is an accurate stream of non-toxic abrasive, gas-propelled through a small, easy-to-use nozzle. The result is a completely *cool* and *shockless* cutting or abrading of even the most fragile hard materials.

Airbrasive has amazing flexibility of operation in the lab or on an automated production line. Use the same tool to frost a large area *or* to make a cut as fine as .008"!...printed circuits...shaping and drilling of germanium and other crystals...deburring fine needles...cleaning off oxide coatings...wire-stripping potentiometers...engraving glass, minerals, ceramics. Jobs that were previously thought impossible are now being done.

Send us samples and specs on your difficult jobs and let us test them for you.

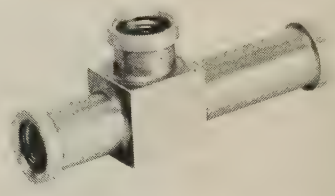
SEND FOR BULLETIN 5705A... complete information.

New dual Model D!

S. S. White Industrial Division
Dept. 21A, 10 East 40th Street, New York 16, N. Y.
Western Office: 1839 West Pico Boulevard, Los Angeles 6, California

Write in No. 184 on Reader Service Card at start of Product Preview Section

VALVE
is dual-purpose unit

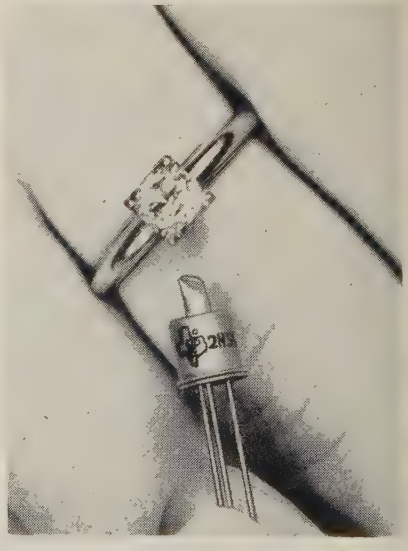


A regulator and relief valve that may be used in accumulators, piston-cylinder actuators, or as a constant pressure source in air, fuel, or lubrication systems is available from **Aero Supply Mfg. Co., Inc., Dept. S/A, Corry, Pa.** It is suitable for the pressurization of a line or tank to a constant value, while simultaneously using fluid from the line or tank.

The valve is being used to pressurize the air side of a bladder in a small auxiliary fuel tank. Characteristics are: inlet pressure, 15 to 70 psig; regulated pressure, 13½ psig (adjustable 10-15 psi); temperature range, —65 to +300 deg F. The valve, which is no bigger than a T-fitting of the line itself, weighs 0.15 lb in the ⅜-in. line size.

Write in No. 295 on Reader Service Card

MESA TRANSISTORS
for ultra-high frequencies



Type 2N559 ultra-high-frequency, diffused-base mesa germanium transistor has switching speeds into the millimicrosec range and a typical alpha cutoff frequency of 250 mc. The unit exceeds Mil-T-19500A says **Texas Instruments, Inc., Dept. S/A, P.O. Box 312, Dallas, Texas.**

The device will dissipate more than 150 mw in free air and will operate up to 100 deg C. It is available in a miniature round-welded case less than half the size of the standard JETEC-TO-5 package.

Write in No. 296 on Reader Service Card

DELCO POWER TRANSISTORS

NEW TYPES

MILITARY
COMMERCIAL

TYPICAL CHARACTERISTICS AT 25°C

EIA	2N297A*	2N297A	2N665**	2N553
Collector Diode Voltage (Max.)	60	60	80	80 volts
HFE (I_c = 0.5A) (Range)	40-100	40-100	40-80	40-80
HFE (I_c = 2A) (Min.)	20	20	20	20
I_{co} (2 volts, 25°C) (Max.)	200	200	50	50 μa
I_{co} (30 volts, 71°C) (Max.)	6	6	2	2 ma
F_{ae} (Min.)	5	5	20	20 kc
T (Max.)	95	95	95	95°C
Therm Res. (Max.)	2	2	2	2° C/W

*Mil. T 19500/36 (Sig. C.)
**Mil. T 19500/58 (Sig. C.)

NOTE: Military Types pass comprehensive electrical tests with a combined acceptance level of 1%.

Delco Radio announces new PNP germanium transistors in 2N553 series — the 2N297A and 2N665, designed to meet military specifications. These transistors are ideal as voltage and current regulators because of their extremely low leakage current characteristics. All are highly efficient in switching circuits and in servo amplifier applications, and all are in *volume* production! Write today for complete engineering data.

DELCO RADIO

Division of General Motors • Kokomo, Indiana

BRANCH OFFICES

Newark, New Jersey
1180 Raymond Boulevard
Tel: Mitchell 2-6165

Santa Monica, California
726 Santa Monica Boulevard
Tel: Exbrook 3-1465

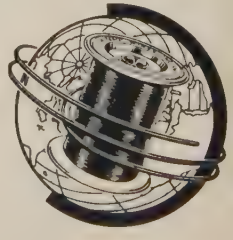
Write in No. 185 on Reader Service Card at start of Product Preview Section

NIKE HERCULES

With deadly accuracy the U.S. Army's new Nike Hercules ground-to-air guided missile streaks out to meet an approaching enemy air force. Its nuclear warhead can wipe out an entire formation.

Western Electric selected Teflon* insulated wire for use in building the alert guidance and control systems of this faster, higher climbing Nike.

As leading specialists in high temperature insulated wires and cables, the men and women at Hitemp are proud of this choice, and the role Teflon wiring plays in giving America a strong new perimeter of defense.

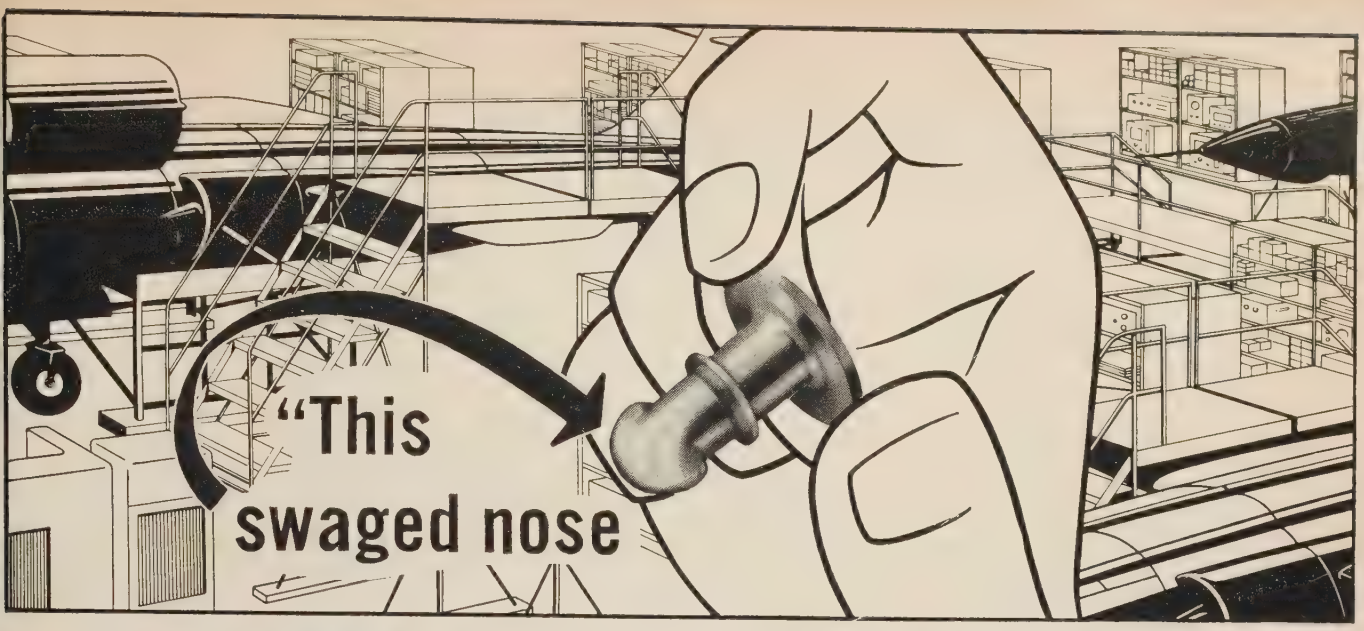


HITEMP WIRES, INC.

1200 SHAMES DRIVE, WESTBURY, NEW YORK

*Du Pont's trade name forTetrafluoroethylene

Write in No. 186 on Reader Service Card at start of Product Preview Section



on LION *Quarter-turn* FASTENERS is the secret of reliability, a high strength-weight ratio and smooth, positive operation."

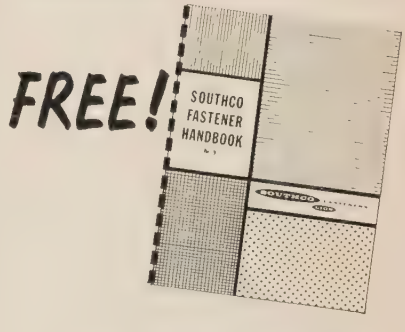
Private, commercial and military aircraft and missile manufacturers' experience with LION QUARTER-TURN FASTENERS for airborne applications and ground operations have justified their choice of these inexpensive, dependable fasteners. They provide quick access through hinged or removable panels. Locking and unlocking is accomplished quickly and smoothly.

Approved for aircraft use—Designed to meet Military Specifications, Lion Quarter-turn Fasteners conform to Mil. Spec. MIL-F-5591A (ASG) . . . are on the Government's QPL . . . are CAA approved for commercial and private aircraft use.

Lion Fasteners consist of three parts . . . a one-piece, swaged-nose stud having no cross pins to install or to become misaligned; a retainer; a floating receptacle which is riveted or welded in place. Installation requires no special tools . . . is simplified by a permissible float of .070".

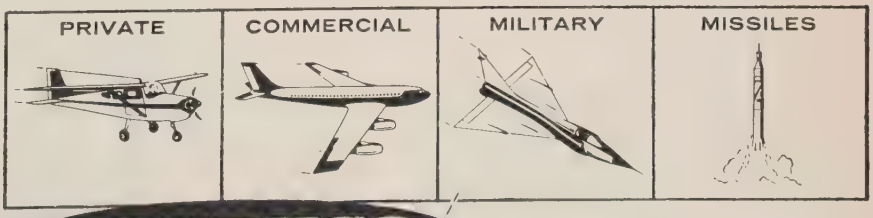
Two types in various sizes available. Model No. 2 is used where space is limited and light weight is essential, Model No. 5 meets severe conditions of shear, tension and vibration.

Full range of heads offers flush, oval, wing, ring, knurled, and notched head and key.



Send for your free copy of Southco Fastener Handbook No. 9 Gives complete engineering data on Lion Fasteners and many other special fasteners. Write to Southco Division, South Chester Corporation, 253 Industrial Highway, Lester, Pa.

LION *Aviation* **FASTENERS**



one of the SOUTHCO FASTENERS LION

©1958

Write in No. 187 on Reader Service Card at start of Product Preview Section

data preview

BEARINGS — [illegible] lubrication [illegible] needle thrust [illegible] and design, and installation [illegible] for use with these [illegible] in Catalog, No. [illegible] by Torrington Co., Dept. [illegible] Torrington, Conn. These bearings have increased capacity ratings.

Write in No. 297 on Reader Service Card

CABLE ASSEMBLIES—H. H. Buggie, Inc., Dept. S/A, Box 817, Toledo, Ohio, covers standard molded-type cable assemblies as well as field, special and coaxial types in its new, 12-page, illustrated catalog. Tabular reference data is given on all types for missile, aircraft, and general application.

Write in No. 298 on Reader Service Card

MANUALS — A four-page, two-color brochure listing technical literature for a variety of commercial and military products, is available from **Manuals, Inc., Dept. S/A, 3033 Excelsior Blvd., Minneapolis 16, Minn.**

Write in No. 299 on Reader Service Card

RELAYS—A 16-page catalog on rugged balanced-armature relays for missile and electronic applications has been published by **Leach Corp., Dept. S/A, 5915 Avalon Blvd., Los Angeles 3, Calif.** Typical environmental ratings indicate that the relays, which include six-pole double-throw types, will withstand vibration of 15 g's to 2000 cps, shock and acceleration of over 50 g's and a temperature range of −70 to 125 deg C.

Write in No. 300 on Reader Service Card

MINIATURE COAX—Electrical standards, temperature rating data, minimum tensile strength and minimum [illegible] elongation standards for its line of miniature coaxial cables have been provided in a four-page catalog available from **Aircraft & Electronics Div., The Rex Corp., Dept. S/A, West Acton, Mass.** Cables are available with all types of plastic insulation meeting or exceeding relevant military specifications and comparable commercial specifications.

Write in No. 301 on Reader Service Card

TEST & SUPPORT EQUIPMENT—Its facilities, aeronautical and missile equipment for testing, and services for transportation industries are discussed in a three-color, illustrated brochure by **Sun Electric Corp., Dept. S/A, 6326 Avondale Ave., Chicago 31, Ill.**

Write in No. 302 on Reader Service Card

TRANSMITTER—The HC-220 transmitter, a general-purpose type for medium-range fixed land stations has been described in Brochure SP72, available from **Marconi's Wireless Telegraph Co., Ltd., Dept S/A, Marconi House, Chelmsford, Essex, England.** The 2½-kw transmitter can operate simultaneously on four crystal-controlled channels and has a range of 1.6 ot 27.5 mc, in two bands.

Write in No. 303 on Reader Service Card

MAGNETIC CORES—SL-106 is a four-page catalog describing the standard ferrite core and core product lines made by **Telemeter Magnetics, Inc., Dept. S/A, 2245 Pontius Ave., Los Angeles 64 Calif.** Specifications are included for storage and switch cores, core arrays, sequential and conversion types of core storage buffers, transistorized computer memory modules, and data translators that make compatible data systems with different codes and formats.

Write in No. 304 on Reader Service Card

TELEMETRY—A reference bulletin that is designed to aid engineers in planning telemetry receiving systems has been issued by **Tele-Dynamics, Inc., Dept S/A, 5000 Parkside Ave., Philadelphia 31, Pa.** Bulletin RST-A-MRMS describes typical FM systems and individual TDI building block components, and it details examples of systems for receiving FM/FM, PAM/FM/FM, and PDM/FM/FM signals.

Write in No. 305 on Reader Service Card

TEST STANDS—Several brochures have been used to describe the wide variety of aircraft engine test stands made by **John Curran, Ltd., Dept. S/A, Curran Rd., Cardiff, Great Britain.** Among the stands are the Type J, designed for jet engines, with a thrust capability of up to 25,000 lb, and the Type W, suitable for piston engines.

Write in No. 306 on Reader Service Card

TECHNICAL FACILITIES—The test and production facilities of its factories have been outlined in a brochure available from **Sir W.G. Armstrong Whitworth Aircraft, Ltd., Dept. S/A, Baginton, Coventry, England.** Seventeen pages are used to discuss electronic test equipment, wind tunnels, computers, and other factors relating to missile and aircraft development and production.

Write in No. 307 on Reader Service Card

COOLING SYSTEMS—A loose-leaf catlog folder has been issued to describe four compact, lightweight electronic cooling packages made by **Pesco Products Div., Borg-Warner Corp., Dept. S/A, 24700 N. Miles Rd., Bedford, O.** The packages are designed for electronics systems requiring air-liquid coolant mediums, and they are particularly adaptable to systems utilizing liquid-cooled power tubes in both airborne and ground installations.

Write in No. 308 on Reader Service Card

POWER SUPPLIES — Its engineering services and complete line of products for special purpose power supplies are described in a 16-page, three color brochure by **Wincharger Corp., Dept. S/A, Sioux City 2, Iowa.** Specifications are included.

Write in No. 309 on Reader Service Card

ANALOG COMPUTER—An eight-page bulletin on a general-purpose analog computer, which provides both cathode ray tube and graph displays of solutions to problems, has been issued by **Short Brothers & Harland, Ltd., Dept. S/A, Queen's Island, Belfast, Ireland.** The computer handles both linear and non-linear systems, and it features automatic drift correction and clamping to eliminate the need for frequent adjustment of the amplifiers in the computing units.

Write in No. 310 on Reader Service Card

ROTARY COMPONENTS — The 16-page Condensed Catalog of Rotary Components describing servo motors, motor tachometer-generators, and synchros has been issued by **Kearfott Co., Inc., Dept. S/A, 1500 Main Ave., Clifton, N.J.** Separate sections review the dominant characteristics of the basic types of each component.

Write in No. 311 on Reader Service Card

RECORDING INSTRUMENTS—Bulletin 362C describing a very small magnetic tape recorder capable of recording instrumentation data on one to 14 channels is one of three data sheets on airborne recording instruments issued by **Leach Corp., Dept. S/A, 18435 Susana Rd., Compton, Calif.** The Model TRA200 triaxial recording accelerometer and the Model MRA440 miniature reed multiple recording accelerometer are described in Bulletins 200D and 440C, respectively.

Write in No. 312 on Reader Service Card

more on page 250

THIS IS THE PLANT THAT QUALITY BUILT!

You, our customers, have made us one of the fastest growing companies in the power supply field.

You have shown us that you appreciate creative engineering, high quality, reliability of performance, and dependable service.

You have indicated time and again your confidence in our company's know-how by repeated purchases of our standard catalog power supplies, and by entrusting to us your most critical custom assignments.

This efficient new plant will permit us to serve you even more effectively.

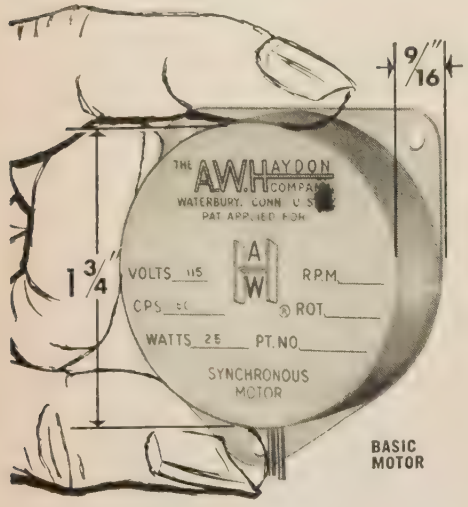
Thank you for making it possible.

NJE CORPORATION
20 Boright Avenue, Kenilworth, New Jersey
Br 2-6000 TWX - Roselle, N. J. 51 FAX - FFP

Write in No. 188 on Reader Service Card at Start of Product Preview Section

ANOTHER FIRST...

THE ONLY *Electro-Reliable* A.C. TIMING MOTOR



BASIC MOTOR

Thinner . . .
Quieter . . .
More Reliable . . .
More Versatile

FINGER-THIN . . .

Only 9/16 Inches Short . . . Only 1¾ Inches in Diameter . . . very compact . . . reduces the size of your equipment.

WHISPER-QUIET . . .

Strictly an electrical motor . . . practically noiseless . . . no rattling of gears or ratchets.

HIGH TORQUE . . .

¼ oz. inch at the rotor with instantaneous start and stop . . . requires only 2½ watts . . . can replace larger motors in recorders, controls and telemetering equipment.

HIGHEST RELIABILITY . . .

Longer life . . . no one-way gears or ratchets to fail . . . provides millions of operations without any trouble.

SPECIFICATIONS

Standard Voltage Ratings:
6, 12, 24, 115, 230 Volts
Frequency:
60 CPS Standard
25, 50 CPS Available
Power Input: 2.5 Watts Maximum (60 CPS)

BASIC MOTOR
Weight: 4 ounces
Speed: 300 RPM
Torque: ¼ oz-in.
Length: 9/16 inch

WITH INTEGRAL GEAR TRAIN
Weight: 5 ounces
Speed: 300 RPM to 1/6 RPH
Torque: 30 oz.-in. @ 1 RPM
Length: ⅞ inch

WITH INTEGRAL GEAR TRAIN

© 1959

Send For Special Illustrated Bulletin AWH MO-806

The A.W. HAYDON *Company*

223 NORTH ELM STREET, WATERBURY 20, CONNECTICUT

Custom Design & Manufacture Of Electronic And Electro-Mechanical Timing Devices

Write in No. 189 on Reader Service Card at start of Product Preview Section

DATA PREVIEW

CAPABILITIES—A booklet, "Capabilities Illustrated," treats the capabilities of **Cook Electric Co., Dept. S/A, 2700 N. Southport Ave., Chicago 14, Ill.** The publication covers a wide range of technologies.
Write in No. 313 on Reader Service Card

PUSHBUTTON ACTUATOR—Charts and data showing uses for basic switches are covered in Data Sheet 155 by **Micro Switch Div., Minneapolis-Honeywell Regulator Co., Dept. S/A, Freeport, Ill.** Typical current and circuitry requirements are discussed.
Write in No. 314 on Reader Service Card

TAPE TEMPERATURE—A general guide to the upper temperature limits of electrical tapes is contained in a brochure by **Minnesota Mining & Mfg. Co., Dept. S/A, 900 Bush Ave., St. Paul, Minn.** A bar graph indicates the relative life of various tape backings.
Write in No. 315 on Reader Service Card

MODULE RELAY—Molded module contact spring construction is described in Bulletin 160 by **Ohmite Mfg. Co., Dept. S/A, 3679 Howard St., Skokie, Ill.** The relays are designated Models TT and TS.
Write in No. 316 on Reader Service Card

FASTENERS—Basic data on fastener types, sizes, threads and plating, designs and applications are contained in an 8-page bulletin by **Standard Pressed Steel Co., Dept. S/A, Jenkintown, Pa.** The bulletin, Form 2449, includes sketches along with specifications.
Write in No. 317 on Reader Service Card

TV MOUNTS—A technical data sheet describing heavy-duty, remote-control mounts for TV cameras has been issued by **Kin Tel Div., Cohu Electronics, Inc., Dept. S/A, Box 623, San Diego 12, Calif.** It is called Data Sheet 6-98.
Write in No. 318 on Reader Service Card

METALS—Three new brochures are available from **J. Bishop & Co., Dept. S/A, Malvern, Pa.** "Metals For Precision and Performance" is a 20-page catalog showing some of the end uses of small diameter stainless steel, nickel and nickel alloy tubing and the company's ability to produce fabricated parts in addition to the redraw operation. "Platinum Products" is for general distribution. "Thermo Element Wires" is a data sheet of interest to companies who either make or employ thermocouples.
Write in No. 319 on Reader Service Card

more on page 252

USE LOTS OF TAPE?

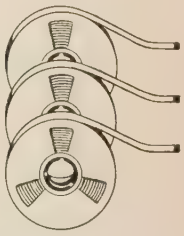
"SCOTCH" BRAND Instrumentation Tapes cut operating costs

Let's develop our own small theory of relativity. For everything's relative, after all—even economy. Clearly, an economy effected now and *corrected* later is no economy at all. In instrumentation tape, there's only one genuine economy—reliable performance. And in performance, the last two words for any acute tape-user are "SCOTCH" BRAND.

First to last, "SCOTCH" BRAND Magnetic Tapes offer uniformity and reliability—born of the experienced 3M technology that created the first practical magnetic tape and continues to advance the art of tape-making day by day.

But let's look at economy from another viewpoint—in terms of some things around the periphery that might not come so readily to mind—storage, use, waste, and time saved.

What other kind of record is so permanent it may last a lifetime, yet requires so little space for storage? Three reels of "SCOTCH" BRAND like those at the right "contain" 30 million characters. What other medium serves input, output and memory functions at such high speeds? Accepts both digital and analogue data?



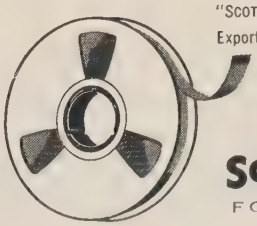
What other kind of record is not *consumed*, even when it is used? "SCOTCH" BRAND Magnetic Tape is run and rerun for analysis, erased and used again, permits retaping with corrections, editing and new data.

Last, but far from least—in these days when time is money, what other medium speeds up data acquisition, reduction and control programming in a way that keeps critical projects rushing forward at full tilt? Or cuts production lead time and human error to a point where a 1000% saving may be realized?

At any cost, "SCOTCH" BRAND Magnetic Tapes would be a good buy. And in every application, "SCOTCH" BRAND Tapes offer that greater economy—reliability. "SCOTCH" BRAND High Resolution Tapes 158 and 159 let you pack more bits per inch, offer extra play reels. "SCOTCH" BRAND Sandwich Tapes 188 and 189 end rub-off, build-up, cut head wear to an absolute minimum, show little wear in 50,000 computer passes. "SCOTCH" BRAND High Output Tape 128 offers top output at low frequencies, even under ambient temperature extremes. "SCOTCH" BRAND Instrumentation Tapes 108 and 109 offer top performance at lowest cost.

Where there's no margin for error, there's no tape like "SCOTCH" BRAND Magnetic Instrumentation Tape. For details, write Magnetic Products Div., 3M Company, Dept. MBV-79, St. Paul 6, Minn., or mail the reader inquiry card. © 1959 3M Co.

"SCOTCH" is a registered trademark of 3M Company, St. Paul 6, Minnesota.
Export: 99 Park Avenue, New York, N.Y. In Canada: London, Ontario.



SCOTCH BRAND MAGNETIC TAPE
FOR INSTRUMENTATION

MINNESOTA MINING AND MANUFACTURING COMPANY
...WHERE RESEARCH IS THE KEY TO TOMORROW

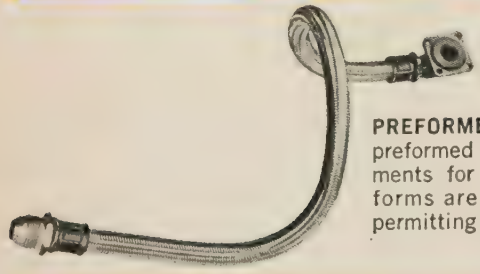
3M COMPANY

Write in No. 190 on Reader Service Card at start of Product Preview Section

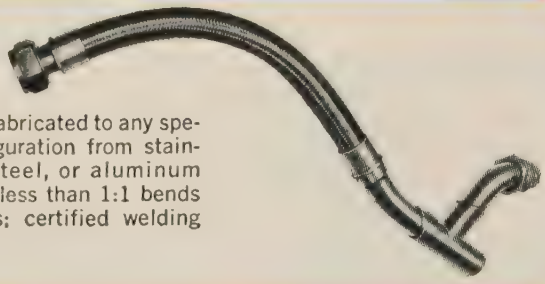
Fluoroflex®-T *(Teflon®)*

PLUMBING

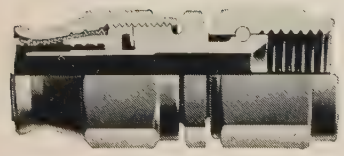
engineered for **SAFETY, RELIABILITY**



PREFORMED CONFIGURATIONS. Factory preformed to meet specific routing requirements for almost any configuration. Preforms are stress relieved at the bends, permitting tighter bend radii than free hose.

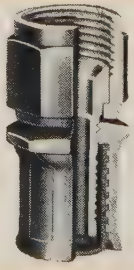


SPECIAL FITTINGS. Fabricated to any specified angle or configuration from stainless steel, carbon steel, or aluminum alloy. Compound and less than 1:1 bends to aircraft tolerances; certified welding and brazing.



SEAL-LOCK FIELD ATTACHABLE, REUSABLE FITTING. Designed for maximum flexibility in teststand and mockup work. Dynamic sealing and triple-locking actions make assemblies leak-proof and blow-off proof. Sizes -3 through -24Z qualified to MIL-H-25579.

SWAGED FIELD ATTACHABLE, PERMANENT FITTINGS. Designed for maximum reliability. Resistoflex swaged fittings have proven their dependability in more than 3 million assemblies. Available in all standard sizes and a variety of configurations including elbows and special attachments.



®Fluoroflex is a Resistoflex trademark, reg., U.S. pat. off.
®Teflon is DuPont's trademark for TFE fluorocarbon resins.

Originators of high temperature fluorocarbon hose assemblies

Resistoflex
CORPORATION
Dept. 272

Offices in principal cities
Roseland, New Jersey • Western Plant: Burbank, Calif. • Southwestern Plant: Dallas, Texas

Write in No. 191 on Reader Service Card at start of Product Preview Section

DATA PREVIEW

SAMPLING SWITCH—A very long life (500 million operations) sampling switch for the high-speed commutating of low-level signals has been described in a folder available from **The Magnavox Co. Research Laboratories, Dept. S/A, 2255 S. Carmelina Ave., Los Angeles 64, Calif.** Maximum contact ratings of ten V and five ma, and a contact resistance of 0.1 ohms are available in units with airborne or ground configurations.

Write in No. 320 on Reader Service Card

POTENTIOMETER—Electrical and mechanical specifications for its standard and special precision potentiometers have been included in a 12-page folder available from **Waters Mfg., Inc., Dept. S/A, Wayland, Mass.** Potentiometers described are in the Bushing and Servo Series.

Write in No. 321 on Reader Service Card

COUPLINGS—Technical Bulletins are available from **Theta Instrument Corp., Dept. S/A, 48 Pine St., E. Paterson, N. J.,** which discusses synchros coupling problems and describes angular dividers. Features, specification, and purchasing information are included.

Write in No. 322 on Reader Service Card

SERVO PARTS—A handy wall chart giving data from MIL-S-20708 and the SAE Specification ARP 461 is available from **Theta Instrument Corp., Dept. S/A, 48 Pine St., E. Paterson, N. J.** It standardizes definition and connection data, and simplifies tasks of synchro manufacturers and users.

Write in No. 323 on Reader Service Card

INSTRUMENTATION—**Columbia Research Laboratories, Dept. S/A, MacDade Blvd. and Bullens Lane, Woodlyn, Pa.,** issued a 14-page, illustrated booklet describing three shock and vibration measuring systems, featuring automatic control, self-calibration and requiring no additional equipment.

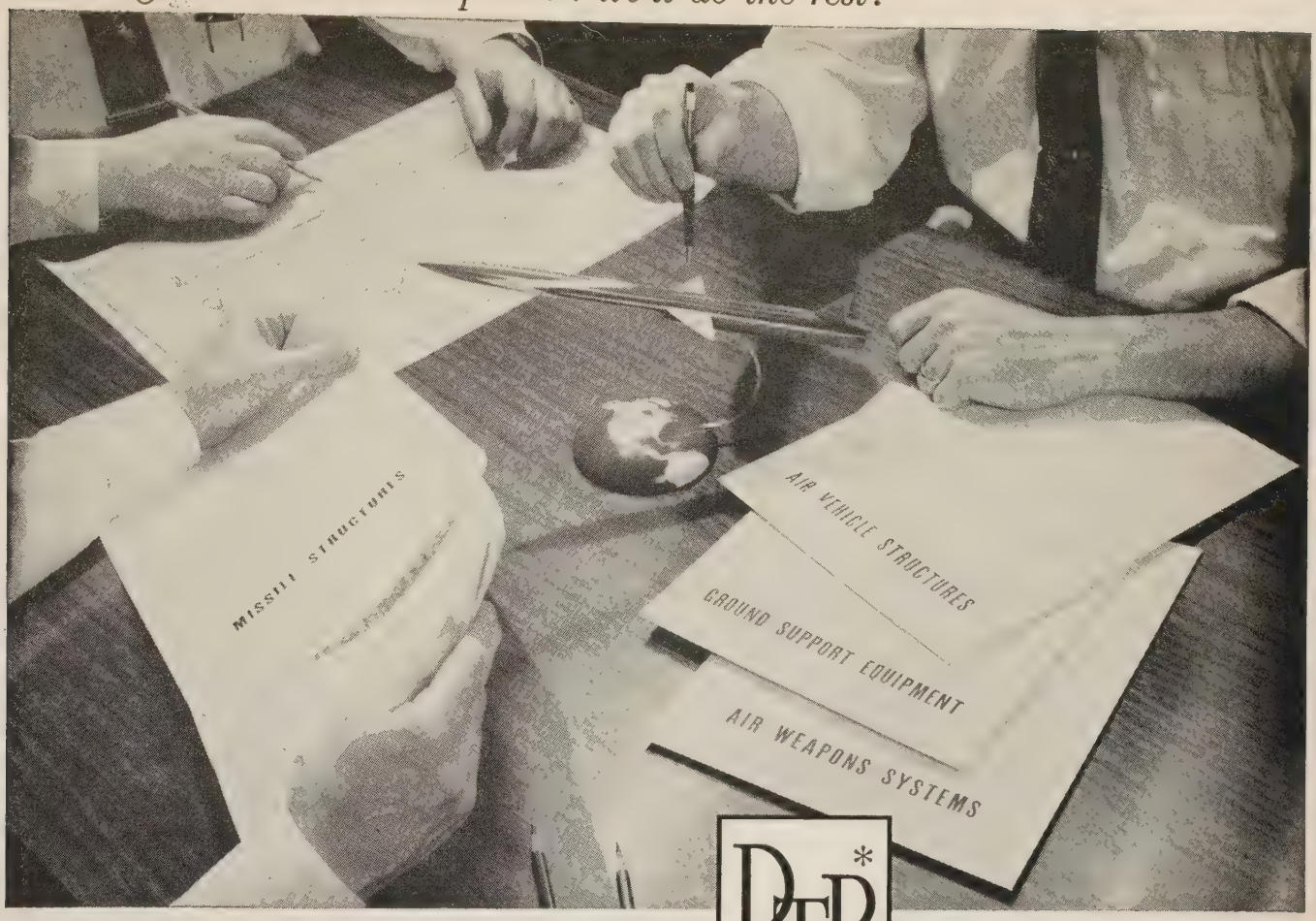
Write in No. 324 on Reader Service Card

CERAMIC STANDOFFS — Detailed physical specifications and prices on 14 basic styles of JAN ceramic standoff insulators in a wide range of sizes have been listed in a four-page catalog, Form 42-181R3, issued by **Centralab Div., Globe-Union, Inc., Dept. S/A, 900 E. Keefe Ave., Milwaukee 1, Wisc.** All of the standoffs are made of grade L-5 material in accordance with JAN-1-8 and JAN-1-10 specifications.

Write in No. 325 on Reader Service Card

more on page 254

Just give us the "envelope"... we'll do the rest!



AERONCA'S DTP* PACKAGES

ASSURE MAXIMUM RESULTS ON PRIME AND SUB-CONTRACT PROJECTS

* *Design Tooling Production*

Contemporary weapons systems, because of their complexity, necessitate sub-contracting of major components, sub-systems and structures. And versatile capabilities... theoretical, technological, mechanical and managerial ... are required to produce these "envelopes" efficiently and economically.

Aeronca has these integrated facilities. That is why we can provide a *Co-ordinated Design, Tooling and Production Service.* This packaged service begins with evaluation of basic environmental data and culminates with "on schedule" deliveries. It has been eminently successful in supporting current operational weapons systems.

Aeronca's leadership is evident in its existing facility for designing and producing ... in quantity ... a complete range of brazed stainless honeycomb structures. This specialized capacity is one of the few *in actual operation* in the industry today.

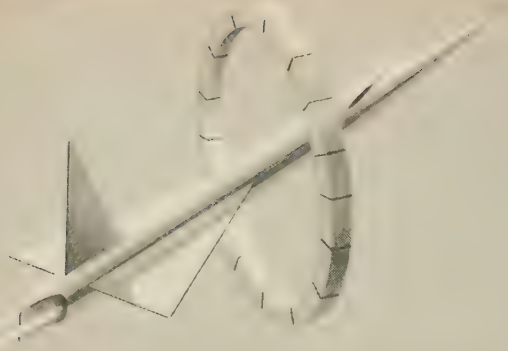
With extensive background in proprietary and sub-contract programs, Aeronca is prepared to work with you on air vehicle, missile, ground support equipment and technical consultation projects. And we can say with confidence ... *just give us the envelope and we'll do the rest.*

AERONCA manufacturing corporation

1724 GERMANTOWN ROAD, MIDDLETOWN, OHIO

6448-AC

Write in No. 192 on Reader Service Card at start of Product Preview Section

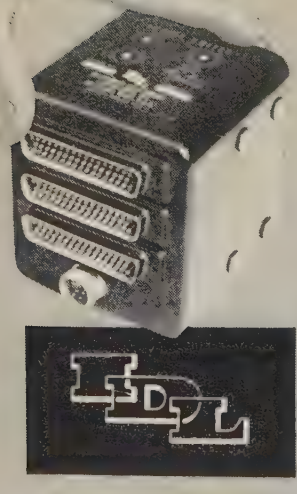


more than **3,000,000,000**
switch closures without failure

Through hermetic seal and attention to engineering detail, IDL's switches and commutators demonstrate this life capability while withstanding missile environment such as vibrations at 2000 cps up to 20g.

The engineering and production experience which created this instrument has also been applied to inertial control, telemetering and radar display systems and to data processing equipments.

These capabilities are fully described in IDL's Brochure, available upon request from the Customer Relations Department.



IDL's Part No. 500263 . . . one of the types of high speed rotary switch, currently being produced for applications such as Sampling, Programming and Telemetering at both high and low signal levels.

INSTRUMENT DEVELOPMENT LABORATORIES

INCORPORATED

67 MECHANIC STREET. ATTLEBORO, MASSACHUSETTS, U.S.A.

A Subsidiary of Royal McBee Corporation

Write in No. 193 on Reader Service Card at start of Product Preview Section

DATA PREVIEW

BRAZING ALLOY—A nickel-base brazing alloy for joining stainless steel surfaces with large clearances is described in Engineering Data Sheet 5 by **Stainless Processing Div., Wall Colmonoy Corp., Dept. S/A, 19345 John R Street, Detroit 3, Mich.** Nominal composition, metallurgical properties and engineering properties are listed.
Write in No. 326 on Reader Service Card

PRECISION FITTINGS—An illustrated technical Engineering Progress Report on "Refinement of Precision Flareless Fittings" has been issued by **Weatherhead Co., Dept. S/A, 300 E. 131st St., Cleveland 8, Ohio.** The report deals with the subject of reliability under thermal shock conditions.
Write in No. 327 on Reader Service Card

HYDRAULIC DRIVES — Power transmissions in 9 to 60 kva ratings for lightweight airborne electrical systems are described in Publication GEA-6890 by **General Electric Co., Dept. S/A, Schenectady 5, N.Y.** Specifications and operating characteristics are included.
Write in No. 328 on Reader Service Card

TOROID INDUCTORS — Uncased, hermetically sealed and plastic encapsulated toroid coils are discussed in Bulletin KT-I by **Kelvin Electric Co., Dept. S/A, 5907 Noble Ave., Van Nuys, Calif.** Specifications, charts, and curves are included.
Write in No. 329 on Reader Service Card

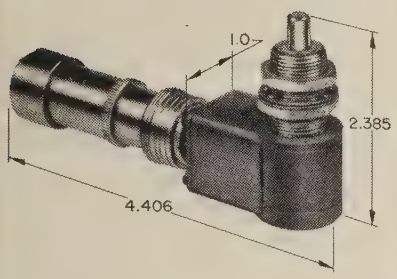
SELECTOR VALVES — Three-position fuel selector valves are described in Bulletin Series 10 by **Gladden Products Corp., Dept. S/A, P. O. Box 1191, Glendale 4, Calif.** The bulletin gives specifications, describes features, and outlines applications.
Write in No. 330 on Reader Service Card

TUBE FORM MOUNTINGS—Full Bonded Tube Form Mountings and Dynaflex Joints for vibration and shock control are discussed in Bulletin 713 by **Lord Mfg. Co., Dept. S/A, 1635 W. 12 St., Erie, Pa.** It contains an application guide.
Write in No. 331 on Reader Service Card

CLAMPS—A bulletin describing and illustrating stainless steel clamps for aviation hose and duct connections has been issued by **Wittek Mfg. Co., Dept. S/A, 4305 W. 24th Place, Chicago 23, Ill.** It is Bulletin AVC-159.
Write in No. 332 on Reader Service Card

more on page 256

Withstand high shock

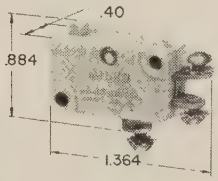


1EN42-R. Used on shipboard launching equipment. Meets requirements of USN Bureau of Ordnance. Catalog 77.

1EN75-R. Used on launching equipment. Meets MIL-S-901B. Also environment and immersion-proof. Catalog 77.

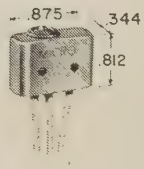
Withstand high temperatures

12HR1-S. Hermetically sealed. Reliable for use up to 600° F. Catalog 77.

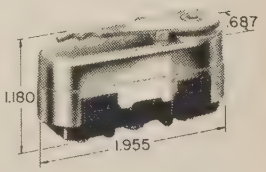


V3-1301. For jets, missiles, electronic gear. Operates reliably up to 600° F. Catalog 74.

Withstand any environment



1SE1. Sealed subminiature switch. Available with variety of actuators. Catalog 78.



1HS1. Hermetically sealed construction (metal to metal and metal to glass seals). Meets MS-25011-1. Catalog 78.

Dependable switches with special capabilities for aircraft, missile and rocket applications

Whether your design calls for a reliable switch to operate under heavy shock conditions, in high temperatures or in quick-changing environments, the MICRO SWITCH line provides the widest selection.

These switches are not only designed to meet critical operating conditions, they are available in a wide variety of sizes, shapes, weights, housings, actuators and electrical characteristics . . . each just right for a specific requirement.

Consultation with MICRO SWITCH application engineers is often the short cut to good design, saving many hours and days of experiments and tests. Such cooperation costs you nothing. It can pay you well to check your switch requirement with MICRO SWITCH.

MICRO SWITCH . . . FREEPORT, ILLINOIS
A division of Honeywell
In Canada: Honeywell Controls Limited, Toronto 17, Ont.

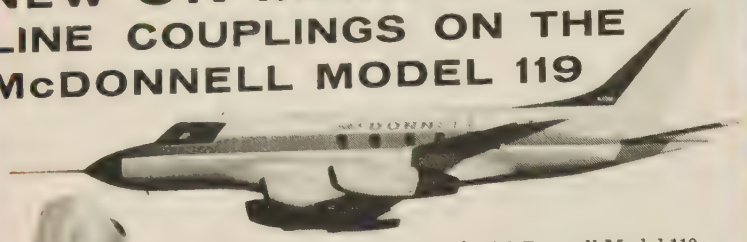
Engineers with many years of experience in aircraft and missile switching problems are at your nearby MICRO SWITCH branch office to assist in your design problem.

Honeywell
MICRO SWITCH Precision Switches

Write in No. 194 on Reader Service Card at start of Product Preview Section

ON MARK COUPLINGS

NEW ON MARK FLEXIBLE LINE COUPLINGS ON THE McDONNELL MODEL 119



Standard equipment on the McDonnell Model 119 fuel lines is ON MARK's new Flexible Fluid Line Couplings. Vastly superior to old style "AN" tube unions, this new coupling has been tested far beyond the requirements of specification MIL-C-25014 with simultaneous flexure, axial motion and pressure cycling at −65°F WITH NO DEVIATION. Simpler in design, easy to assemble (NO SPECIAL TOOLS NEEDED), and lighter, the ON MARK coupling seals on deformed, marred and scratched tubing at all temperatures. Tests prove these couplings to be equally effective for special requirements such as hot air, gases, exotic fuels, and vacuum. *In production* in standard tubing sizes.

For full information please contact

ON MARK COUPLINGS, INC.

4440 York Boulevard, Los Angeles 41, California

Telephone CLinton 4-2278

Representatives: Airsupply Company, Beverly Hills, Calif.; Aero Engineering Company, Mineola, Long Island, N.Y.—Divisions of The Garrett Corporation; Aviation Electric, Ltd., Montreal, Quebec, Canada

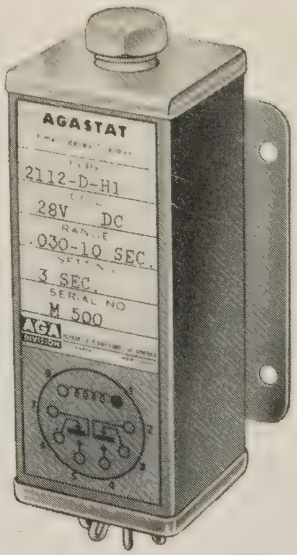
Write in No. 195 on Reader Service Card at start of Product Preview Section

NOW!

MINIATURE AGASTAT®

time/delay/relay

MEASURES ONLY 4"x1½"x1½"



The Miniature Agastat time delay relay is a space-saving answer to aircraft, missile and computer problems. You get all these valuable features in one small package:

- Easily adjusted timing ranges as short as .030 seconds.
- Repeat accuracy of ± 5%.
- Time delay on energizing or de-energizing.
- For DC or AC operation.
- Hermetically sealed or dust-proof housings.

Write today for the full details on the new miniature Agastat. Dept. A36-719.

AGA DIVISION

ELASTIC STOP NUT CORPORATION OF AMERICA

1027 Newark Avenue, Elizabeth, N. J.

Gasaccumulator Co., (Canada) Ltd., 12 Gower Street, Toronto 16, Ontario

Write in No. 196 on Reader Service Card at start of Product Preview Section

DATA PREVIEW

SILICONES—The use of silicones to aid in miniaturization and weight reduction of missiles and missile components, and to increase their reliability is covered in "Silicones in Missile Design," available from **Dow Corning Corp., Dept. S/A, Midland, Mich.** The eight-page brochures provides designers with a ready reference to many missile and rocket applications for silicone rubbers, resins, dielectrics, fluids, greases, and compounds.

Write in No. 333 on Reader Service Card

PRESSURE TRANSDUCERS—Three instrumentation bulletins describing a series of high performance pressure transducers have been issued by **BJ Electronics Div., Borg-Warner Corp., Dept. S/A, 330 Newport Blvd., Santa Ana, Calif.**, on the DP-7 pressure transducer, GP-15D high range pressure transducer, and DP-15D high range differential pressure transducer.

Write in No. 334 on Reader Service Card

CONVERSION COATINGS—**American Chemical Paint Co., Dept. S/A, Ambler 1, Pa.**, is offering a new eight-page brochure describing various chemical conversion coatings for steel, aluminum, galvanized iron, zinc and cadmium plated surfaces; for corrosion resistance, paint bonding, drawing and forming and protection for friction surfaces. Also listed are current specification chemicals for the Government and its contractors.

Write in No. 335 on Reader Service Card

VOLTAGE REGULATOR—Bulletin 1.050 is a catalog sheet on precision filament voltage regulators made by **Electric Regulator Corp., Dept. S/A, Pearl St., Norwalk, Conn.** The Series 1.050 units, which operate from 115 V input and provide an output of 6.3 V in various current ranges, are designed for ±0.10 per cent rms regulation against line and load and operation at frequencies from 50 to 1600 cps.

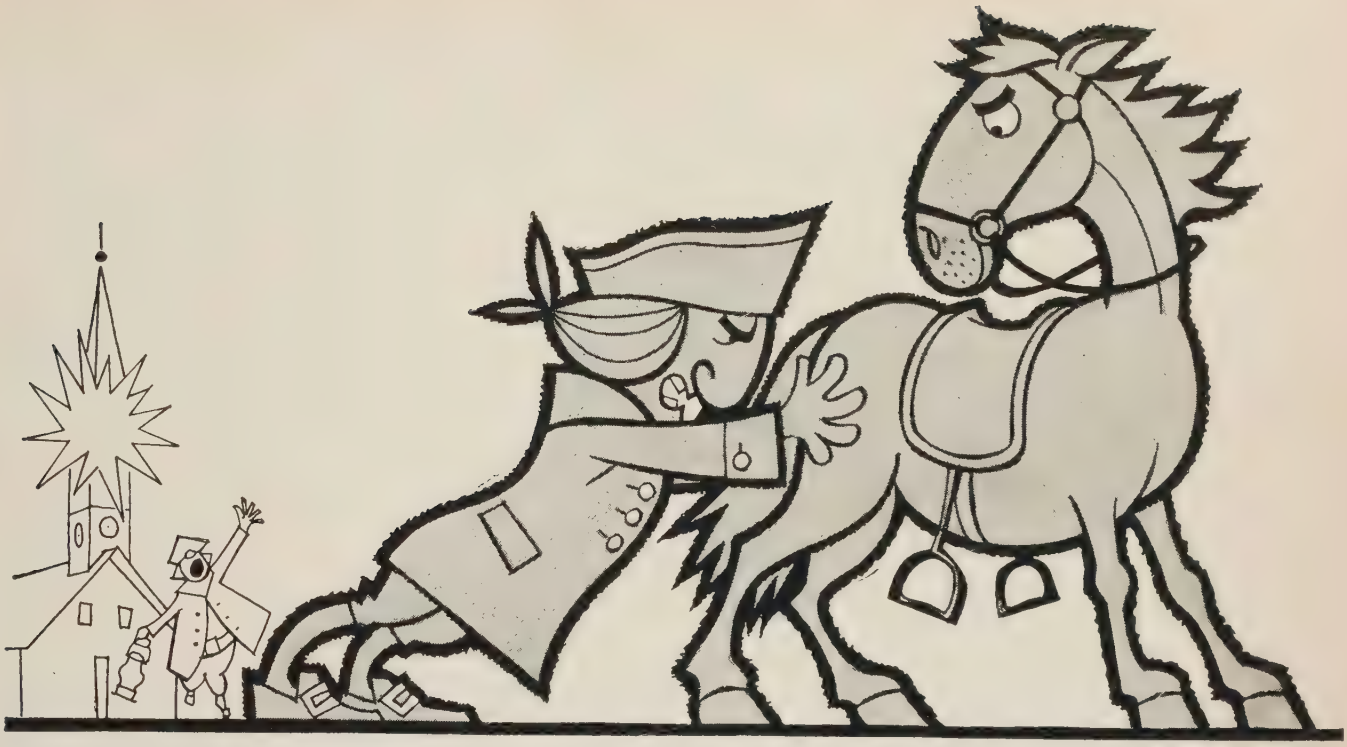
Write in No. 336 on Reader Service Card

FLEXIBLE COUPLINGS—Comprehensive design and application data on the Amerigear Series GG continuous-sleeve flexible couplings have been compiled in the four-page Bulletin 502 by **Mechanical Power Transmission Div., Zurn Industries, Inc., Dept. S/A, Erie, Pa.** Proper-selection data, recommended lubrication specifications, and detailed assembly and disassembly instructions are among the points covered.

Write in No. 337 on Reader Service Card

more on page 260

Man's Eternal Struggle with the Machine



THE REQUIREMENTS OF THE SPACE AGE DEMAND MORE FROM MACHINES AND TECHNIQUES THAN EVER BEFORE

Will the conquest of space wait while you make new machines work right?

Hardly! Not when the competition is boasting they'll bury us all.

Your job is to produce missiles and space craft. That's a full-time job in itself. Your responsibility for specifying equipment and processes only adds to that work-load. Obviously, you can't afford to be buried under new machines that can't be qualified and certified in the shortest time with the least expense and effort.

Sciaky knows you have to produce on time and to the most rigid specifications. That's why Sciaky's responsibility just *begins* with equipment design and manufacture. That's why Sciaky welding machines are fully tested and proved to do *your* job *before shipment.* That's why Sciaky machines are commonly installed, qualified, and certified in the shortest possible time. And, that's why Sciaky Service Engineers are ready to back you fully.

Why take less than the full advantage of talking with a Sciaky Application Engineer when you are considering equipment. No obligation, of course.

The aviation industry has been taking that advantage ever since Sciaky machines made it possible to resistance weld aluminum in production. The entire Sciaky organization has been built by satisfying people just like you. As a result, Sciaky has produced almost all the basic advances to the technology of resistance welding since the year 1917.

SCIAKY

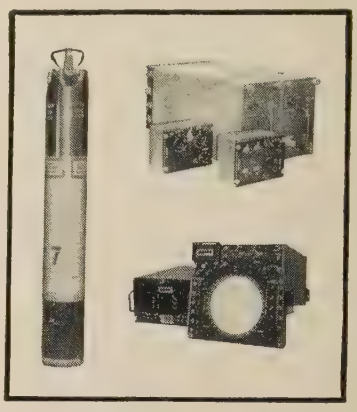
73A

SCIAKY BROS., INC., 4912 W. 67th STREET, CHICAGO 38, ILLINOIS • POrtsmouth 7-5600

Write in No. 197 on Reader Service Card at start of Product Preview Section

AN ASW SYSTEM...DISPLAY/AIRBORNE RECEIVER/SONOBUOYS

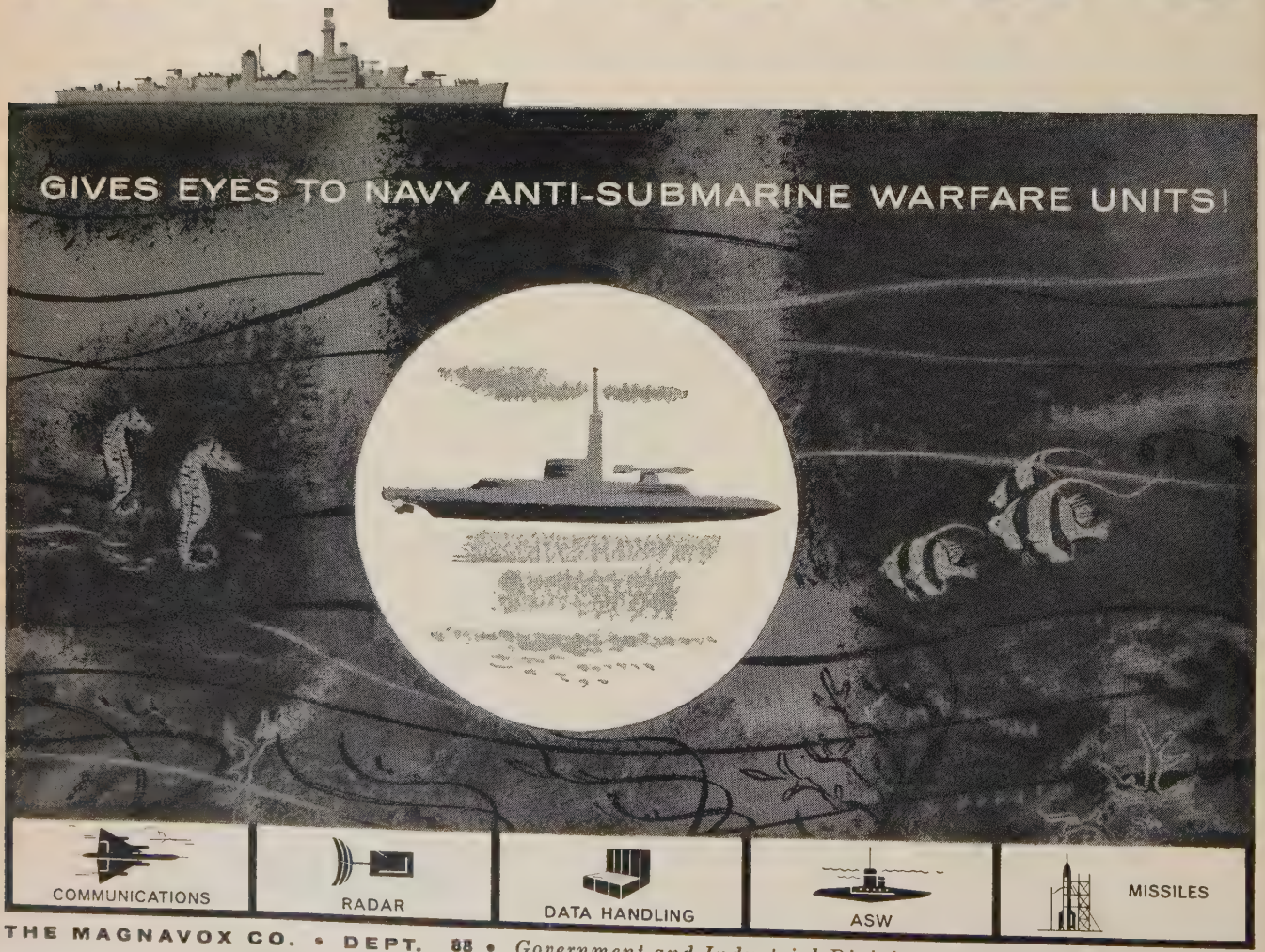
Anti-submarine warfare equipment designed, developed and produced by *The Magnavox Company*, in conjunction with the Navy Department, provides patrol aircraft with eyes that see underwater by day and by night. The AN/ASA-16 Display System, together with SONOBUOYS, AN/ARR-26 Receiver systems and other associated equipment provide aircraft with a clear picture of the ocean-depths below them. They are part of the continuing contributions of *The Magnavox Company* in aiding the U.S. Navy to combat the growing submarine menace.



MAGNAVOX capabilities are in The Fields Of Airborne Radar, ASW, Communications, Navigation Equipments, Fusing and Data Handling . . . your inquiries are invited.

PRODUCTS
THAT SEE BY
THEMSELVES

Magnavox



THE MAGNAVOX CO. • DEPT. 88 • *Government and Industrial Division* • FORT WAYNE, IND.

Write in No. 198 on Reader Service Card at start of Product Preview Section

Mission: **MAN IN SPACE**

Filter Application: **PROTECT HYDRAULIC CONTROLS**

Filter: **PUROLATOR**

A malfunction in the lines of the hydraulic and pneumatic controls of the X-15 could send it off its programmed trajectory . . . alter the angle of re-entry . . . cause deviation from the ballistic arc.

Purolator filters are on the X-15 to protect the control systems. Three new filtering applications were worked out for North American Aviation, designers and builders of the X-15, by Purolator engineers to meet the space-age requirements of the manned missile.

Filters for crucial aircraft and missile requirements are a specialty at Purolator . . . and every application is considered as crucial as those on the X-15. Draw on Purolator's experience to help you handle your filtration requirements. A phone call or a descriptive letter, with plans or blueprints, will receive prompt attention.

Filtration For Every Known Fluid

PUROLATOR

PRODUCTS, INC.

Rahway, New Jersey and Toronto, Ontario, Canada

Write in No. 199 on Reader Service Card at start of Product Preview Section

NOW! from SIKORSKY AIRCRAFT

Proof Positive that LAMINUM® LAMINATED SHIMS

Save Time! Save Money! Improve Quality!

● This technician is with Sikorsky Aircraft, Division of United Aircraft Corporation at Stratford, Connecticut. He is placing a 12½" diameter LAMINUM shim on an input assembly. In foreground are other LAMINUM shims. Notwithstanding extremely close assembly tolerances, Sikorsky saves time and cuts costs by using Laminum. No need for micrometer checking, no need for standby grinding or machining. Laminum Shims simply p-e-e-l for a thousandth fit, right at the job. That's why a long list of aircraft as well as missile and rocket producers benefit from the use of laminated shims of LAMINUM.

LAMINUM®
the solid Shim that p-e-e-l-s for adjustment

Laminum looks, acts like solid metal—yet quickly p-e-e-l-s to precision fit right at the job. In Brass, Mild Steel, Type 302 Stainless with .003" or .002" laminations. In Aluminum with .003" laminations or NEW with .002" laminations. Custom-made, Laminum Shims eliminate extra operations: no machining, no grinding, no stacking, no miking. *And no grit between layers—ever!*

FREE! Actual sample of LAMINUM—also illustrated Engineering Data File. Write for your copy today.

LAMINATED SHIM COMPANY, INC.

EAST COAST
Home Office and Plant
5307 Union Street
Glenbrook, Conn.

WEST COAST
Sales Office
600 Sixteenth St.
Oakland 12, Calif.

Write in No. 200 on Reader Service Card at start of Product Preview Section

260

DATA PREVIEW

ADJUSTABLE UNION—A catalog describing an adjustable flareless union as an assembly aid in hydraulic and fluid systems requiring high space utilization has been issued by **The Weatherhead Co., Dept. S/A, 300 E. 131st St., Cleveland, Ohio.** The union is for aircraft and missile application.
Write in No. 338 on Reader Service Card

PRESSURE STANDARD—A pneumatic, deadweight piston gage for calibration of pressure-measuring instruments is described in Bulletin 1581A, available from **Consolidated Electrodynamics Corp., Dept. S/A, 300 N. Sierra Madre Villa, Pasadena, Calif.** The Type 6-201 primary pressure standard covers six pressure ranges from 1.5 to 500 psi, with a minimum pressure of 0.3 psi.
Write in No. 339 on Reader Service Card

BRAZING STEELS—"How to Braze Stainless Steels" is discussed in detail in a booklet by **Harper Electric Furnace Corp., Dept. S/A, 39 River St., Buffalo 2, N.Y.** It details characteristics of base and filler metals, brazing cycles, selecting and using gas atmospheres, and construction and application of various types of furnaces.
Write in No. 340 on Reader Service Card

TUBING—A tubing chart which explains the method for calculating the tube size required to machine to a finished dimension has been prepared by **Peter A. Frasse & Co., Dept. S/A, 17 Grand St., N.Y. 13, N.Y.** The chart gives typical examples.
Write in No. 341 on Reader Service Card

SHOP FACILITIES—A brochure on "space age" contract manufacturing showing the scope of manufacturing capabilities in a quick reference manual has been issued by **Farwell Metal Fabricating, Dept. S/A, 81 W. Fairfield Ave., St. Paul 7, Minn.** Another brochure lists all equipment by department under "Facilities and Equipment".
Write in No. 342 on Reader Service Card

ELECTROMECHANICS — Increasing applications of electromechanical actuating equipment in control systems in aircraft, missiles, electronics, and other fields has sparked preparation of the Electro-Mechanical Actuator Glossary by **Hoover Electric Co., Dept. S/A, Hangar Two, Port Columbus Airport, Columbus 19, O.** The glossary seeks to contribute to a better understanding of the design parameters involved.
Write in No. 343 on Reader Service Card

Reeves INSTRUMENT CORPORATION *is part of the picture on front page projects of today.*

PRECISION...ON A SPACE-HIGH PEDESTAL

Reeves has pioneered in the development of extremely high precision two- and three-axis antenna pedestals for fire control, guidance and tracking systems. Reeves-engineered pedestals and related electronic assemblies, including servo systems and computers, are production-ready in types for both land-based and shipboard applications. The pedestals provide continuous rotation in azimuth, with angular travel in the remaining two axes designed to meet particular requirements. Accuracies in the order of 0.1 milliradians can be achieved, with rates of 10 degrees per second, or higher.

REEVES INSTRUMENT CORPORATION

A Subsidiary of Dynamics Corporation of America

Roosevelt Field, Garden City, New York

Qualified engineers who are seeking rewarding opportunities for their talents in this and related fields are invited to get in touch with us.

Front page projects of tomorrow are part of the picture at Reeves INSTRUMENT CORPORATION

6RV59

dead center

Kelsey-Hayes thrust vectoring systems give missiles proper directional control.

Kelsey-Hayes is contributing substantially to the design, development and production of new thrust vector control systems for solid fuel propulsion.

For example Kelsey-Hayes, in a recent crash program, designed and fabricated a movable nozzle control that passed static firing tests for one of the newest sophisticated missile systems.

The swivel nozzle control is just one of the latest developments by Kelsey-Hayes as a subcontractor of propulsion subsystems, flight componentry and high performance materials. Spearheading Kelsey-Hayes activities is the Advanced Design Group, a flexible team of experienced design specialists.
Kelsey-Hayes Company,
Detroit 32, Michigan.

KELSEY HAYES COMPANY

Automotive, Aviation and Agricultural Parts
Hand Tools for Industry and Home

18 PLANTS: Detroit and Jackson, Michigan; Los Angeles; Philadelphia and McKeesport, Pennsylvania; Springfield, Ohio; New Hartford and Utica, New York; Davenport, Iowa; Windsor, Ontario, Canada.

Metric survey returns

Returns from SPACE/AERONAUTICS' *"Metric Survey" questionnaire in the May 1959 issue are still coming in. Here are some of the comments made by our readers.*

"Superior mental tool"

In my experience with both systems (in the U.S., S. America and Europe), I find the metric system much superior as a mental tool, as an aid to visualization, and as a logical system of measurement for production.

Westinghouse Electric Corp. (Air Arm Div.) Baltimore, Md. — P. A. Castruccio, Director Astronautics

Change to metric! Your efforts are highly appreciated.

Gas Turbine Dept. Lycoming Division of AVCO — U. Breiv, Development Engineer

Space technology embraces all technology. Difficult to legislate; doubt Congress would ever act. Urge all members of technical societies to use metric and urge technical schools to adopt metric in teaching and text books.

U. S. Naval Air Development Center Johnsville, Pa. — Richard F. Scharmann, Supervising Engineer Control & Guidance

"Don't drop this fight!"

Thanks for 'tooting the horn'! Please don't drop this fight! The sooner we convert to metric system the better.

Boeing Airplane Co. — Imanta Ikstrums, Research Engr.

"Why not now?"

The metric system offers the best method for accurate and universal weights and measures. We must adopt it eventually, why not now?

Engineering Master Scheduling Lockheed Missiles & Space Division Sunnyvale, Calif. — F. U. Nelson Eng. Ops. Coordinator

"Catastrophic Chaos"

The need for conversion to metric or C.G.S. units is nowhere felt more than in the thermodynamic and heat transfer fields where the results of erroneous conversion lead to catastrophic chaos.

College of Engineering University of California — Don O. Horning Research Engineer

"Small price for further accuracy"

I realize that such a change would necessitate new equipment on my part, but I feel that this is a small price for further accuracy and reliability.

Lear, Inc., Astronautics Div. — Lyle E. Bell Mechanical Designer

Many persons were opposed to changes from statute to nautical miles and knots, from gallons to pounds of fuel and from local to Greenwich time, but we are making good progress and will benefit from the changes.

Norair Div., Northrop Corp. El Paso, Texas — R. E. Close Base Admin.

"Not worth rewards"

With electronic computers doing heavy duty computation work, I think lost time in gaining 'feel' for significance of values would not be worth rewards of a somewhat more orderly system.

Mechanical Research, Thermodynamic Gp., Lockheed Aircraft Corp. Burbank, Calif. — Philip S. Starrett Gp. Engineer

Conversions in English system worse

Not only would the accuracy be improved, but many hours saved. The conversions within the English system itself, from inches to feet, from ounces to pounds, etc., with the many necessary tables would be rendered unnecessary. This takes even more time than conversion from English to metric. It is high time to become logical and efficient! You are to be thanked and congratulated on having taken up this important question!

Ford Instrument Co. New York — S. Rappaport Project Supr.

Cost of enforced changes would be tremendous. A gradual change would bog down by inertia, unless a continuing incentive is provided. If military procurement specs were in metric, cost of changes would be cost of getting business.

Hamilton Standard Windsor Locks, Conn. — David C. Jennings, Sr. Analytical Engr.

"How much does a cubic yard of water weigh?"

Keep it up! Ask any engineer how much a cubic yard of water weighs! Nobody knows—yet one cu meter of water equals 1000 kg!

Unitec Inc. Erie, Pa. — Stephen J. Zand Vice Pres.

"Speed up my work"

Feel that the metric system would speed up my work appreciably. Also reduce possibility of errors and simplify drawings which now have a mixture of fractional and decimal numbers expressing loads, dimensions and tolerances. I have long hoped that someone would start a movement for change to metric system. Best wishes for success.

N. American Aviation, Inc. Los Angeles, Calif. — Terry Allen, Sr. Engr., Spring Design

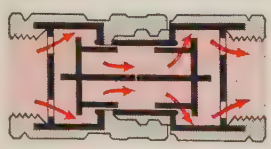
"Fine public service"

Your survey is a fine public service.

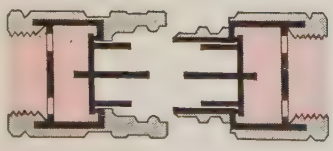
Hughes Tool Co., Aero Div. California — J. P. Dallas Supervisor, Equipment Test Lab

There's a size and type to handle almost anything that flows

TO USE SNAP-TITE VALVED COUPLING:



CONNECT—Full flow instantly



DISCONNECT—No flow instantly

Snap-Tite can provide the right size valved coupling for most any use . . . with quick off-on action wherever coupling or shut-off is required.

"H" series valved couplings for high pressure applications. High resistance to heavy line surge. Sizes from 1/8" through 6". Larger sizes on special order.

"IH" series valved couplings for greater impact in air lines. 1/8" through 1/2".

"E" series valved couplings for vacuum and very low pressure. Recommended for gravity flow. Sizes from 1/8" to 6". Larger sizes on special order.

"T" series valved couplings for hard to handle fluids. The only valved quick-disconnect couplings now on the market for fluid temperatures from −40°F to +400°F. Sizes from 1/2" through 3".

Snap-Tite valved couplings are available with two-way or one-way automatic line shut-off. They are normally furnished in alloy steel. Also available in brass, aluminum, or stainless steel with a variety of finishes.

Write for Snap-Tite Catalog No. 58 for more information on Snap-Tite valved couplings.

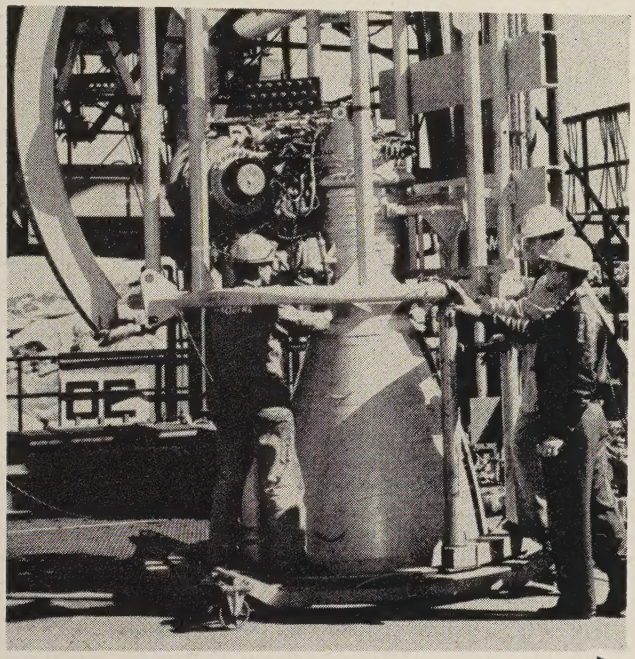
★Snap-Tite

UNION CITY, PA.

ST-59-02

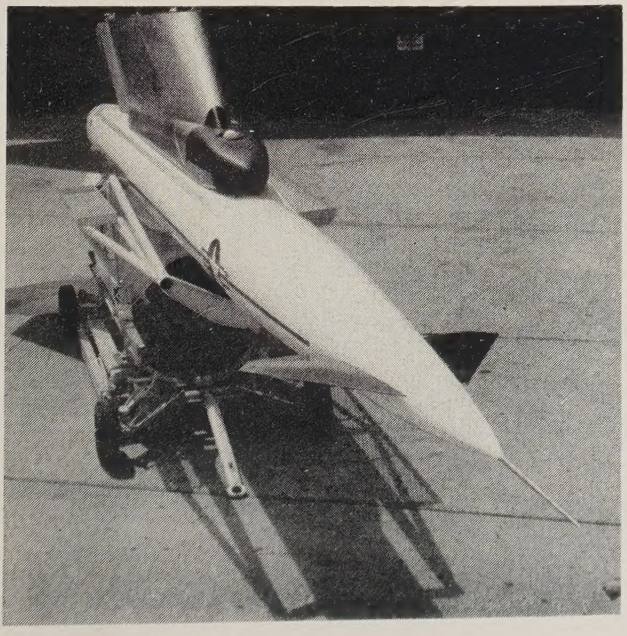
Write in No. 202 on Reader Service Card at start of Product Preview Section

industry briefs

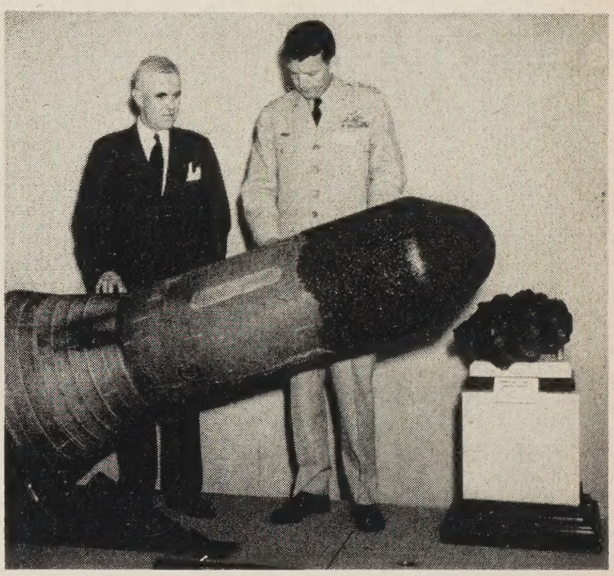


FIRST ICBM NOSE CONE ever to be recovered is looked over by Lt. Gen. B. A. Schriever, ARDC's commander, and Avco president K. R. Wilson, Jr. The lump at right is a meteorite. The cone was protected by a heat-resistant material developed by Avco.

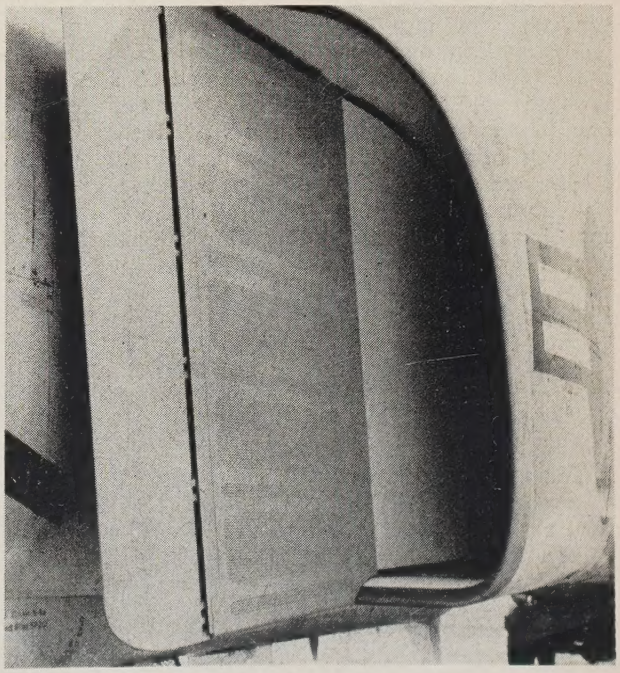
FIRST FULL-SCALE MOCKUP of North American's GAM-77 Hound Dog air-to-air missile was shown recently. Two of the 42-ft-long, inertially guided birds are to be carried under the wings of a Boeing B-52.



FIRST OF EIGHT Rocketdyne H-1 liquid propellant engines to be clustered in the Saturn space vehicle's booster was delivered to the Army Ballistic Missile Agency at Huntsville, Ala. Total thrust of the cluster will range up to 1,500,000 lb. Four of the cluster's engines will be gimbaled to provide attitude control.



SOPHISTICATED DESIGN of the intake scoop of McDonnell's twin-jet, all-weather F4H-1 fighter bomber is shown by a variable ramp. Also visible is a Raytheon Sparrow III missile, fitted flush to the plane's belly.



Better communications betw een systems groups!

by A. B. Barnes, Development Engineer,
The de Havilland Aircraft of Canada Ltd.
Guided Missiles Div., Downsview, Ontario

THE REPERCUSSIONS of the weapon system concept haven't been confined to the military. This concept has deeply affected every type of technical device with complex, interlocked parameters. Unfortunately, it hasn't yet been carried far enough.

The space vehicle, which is just around the corner, will be one of the most complex functional systems ever devised. More than any other machine it will depend on the best possible systems integration.

Many arts and sciences are involved in the successful development and use of such a vehicle. As a result, we need, more than ever before, "specialists" who have a basic knowledge of every other branch of science and even of philosophy. The aerodynamicist, to cite just one example, must learn all about magnetohydrodynamics.

If we look at the most complex of all systems, nature, we find a simple though somewhat cruel systems concept: the survival of the fittest, natural selection. In nature, all possible system modifications are eventually tried out, and the best are automatically chosen and retained.

We can learn many laws of survival from nature in a situation in which survival may depend on a system's effectiveness. We can learn that our future complex system is apt to be unsatisfactory unless it is flexible enough for easy improvement. Alternatively, we must produce a large number of basically different models.

Unfortunately, our more direct approach to development has some built-in drawbacks. We haven't yet developed fully integrated systems. Rather we've produced many subsystems and joined them together as painlessly as possible.

The horse did not develop as head, body, legs, and tail separately and was then joined together. It developed as a unit horse. If our future systems are to have top effectiveness, they must be developed more and more in this way.

You may ask, how can we develop a rocket vehicle as a vehicle, and not as an airframe, a guidance system, a propulsion unit, and so on? The answer is, of course, that we can't—yet. But we can make a start by evaluating the effect of subsystem in each other more closely than ever before.

It no longer is enough to specify environmental conditions in terms of straight environment to the subsystem contractor. The subsystems man must say what his hardware will contribute to the environment, and circulate this data to other subsystems people. Acute interdependability of parts arises; and every subsystem part overlap raises reliability and reduces weight.

For instance, if we have a vehicle whose plasma jet uses liquid hydrogen and whose cryogenic guidance electronics requires cooling to nearly absolute zero, then logically the electronics should be in the fuel tank.

This type of thinking has already been applied, though not as a result of a concerted new design approach. On the 707, Boeing wanted to use water injection for extra thrust at takeoff. Unfortunately, there was no space aboard for the water tank. So Boeing engineers looked for large, hollow airframe members —and hit on the idea of using the keel beam.

Beyond the weapon system concept

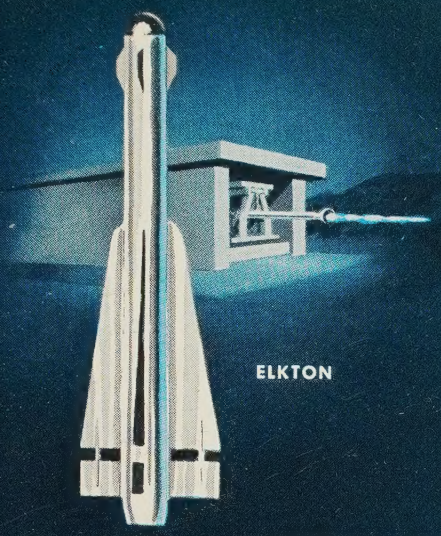
The weapon system concept partially solves our immediate problem. It is inadequate because the prime contractor tends to split up his activities among different groups between which there is not enough communication. Subsystems are assessed individually on their merit instead of as part of a major complex device.

The project and development engineer must always be alert for short cuts by multi-purpose subsystems constituents. Therefore he must be much more familiar with the system element possibilities. In an age where specialization seems to offer the most direct solutions, it may actually be a superficial way out. More and more "multi-channeled" ability is a must at every level of system development.

Some means is needed to get an adequate exchange of facts between various systems groups: regular meetings of key personnel or some sort of computation method. The latter has great promise, but would be very involved. Interlocking of parameters as well as systems makes it a tough job.

For the immediate future, a much simpler, direct approach is needed—personal contact between individuals. In fact, efforts along these lines are slowly being made. Some outfits have regular, unchaired discussions just to exchange project knowledge.

Certainly general meetings of this type must be free of the fetters that usually restrain discussion. There must be as many "crosslinks" (usually in the form of "crossfire") as possible. The participants must be of such technical strength that, upon hearing an idea better than their own, they can adopt it right away.—End



ELKTON

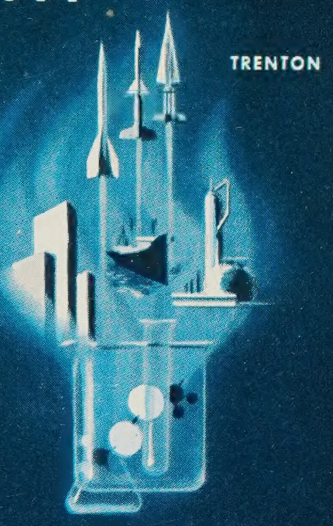
REDSTONE

LONGHORN

THIS IS THIOKOL...

serving industry and the national defense

DENVILLE

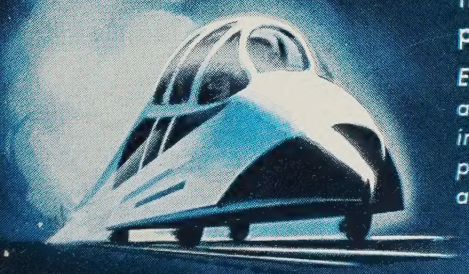


TRENTON

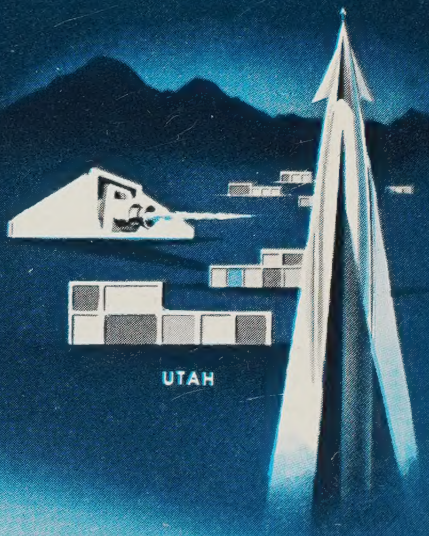
In modern plants strategically situated throughout the country, Thiokol is making many significant contributions to the art and science of rocketry.

By developing new and better propellants (both solid and liquid)—by designing and building improved power plants to utilize these fuels—by furnishing essential support equipment . . . Thiokol helps to strengthen the nation's defenses, helps push back our spatial frontiers.

Engineers, Scientists: perhaps there's a place for you in Thiokol's expanding organization. Our new projects present challenging problems and a chance for greater responsibility.



BRISTOL



UTAH

Thiokol® CHEMICAL CORPORATION

TRENTON, N. J. • ELKTON, MD. • HUNTSVILLE, ALA. • MARSHALL, TEXAS
MOSS POINT, MISS. • BRIGHAM CITY, UTAH • DENVILLE, N. J. • BRISTOL, PA.

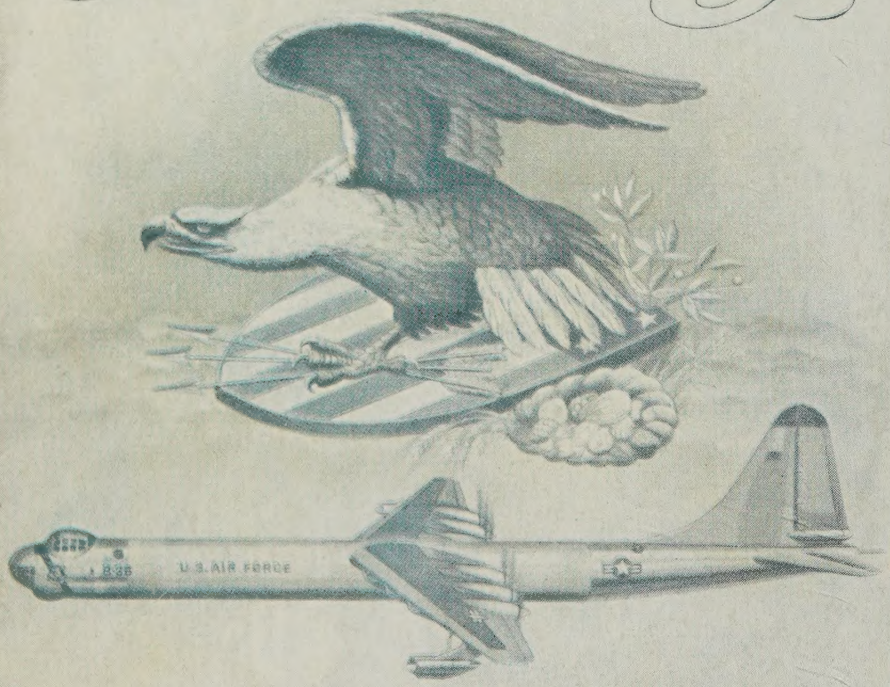
®Registered trademark of the Thiokol Chemical Corporation for its liquid polymers, rocket propellants, plasticizers and other chemical products.

Write in No. 3 on Reader Service Card at start of Product Preview Section

PROPERTY OF
CHICAGO MIDWAY LABORATORIES

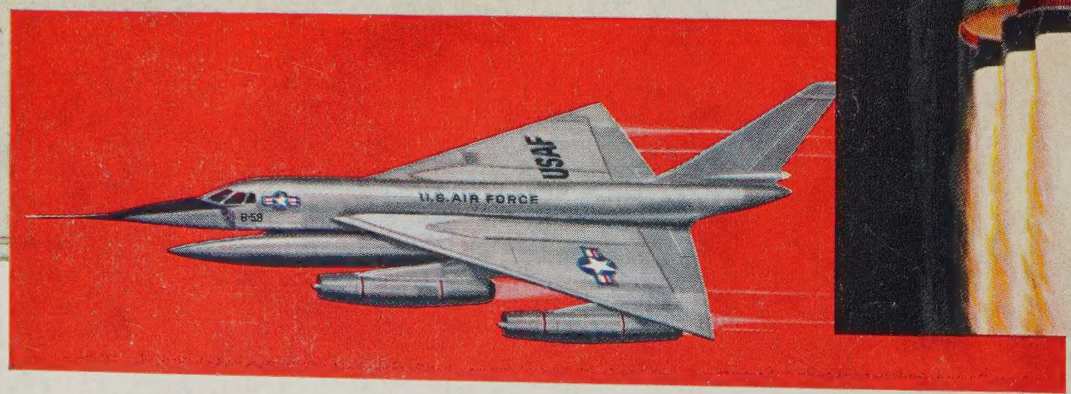
THE U.S.A.F. STRATEGIC AIR COMMAND - UNDERWRITERS OF

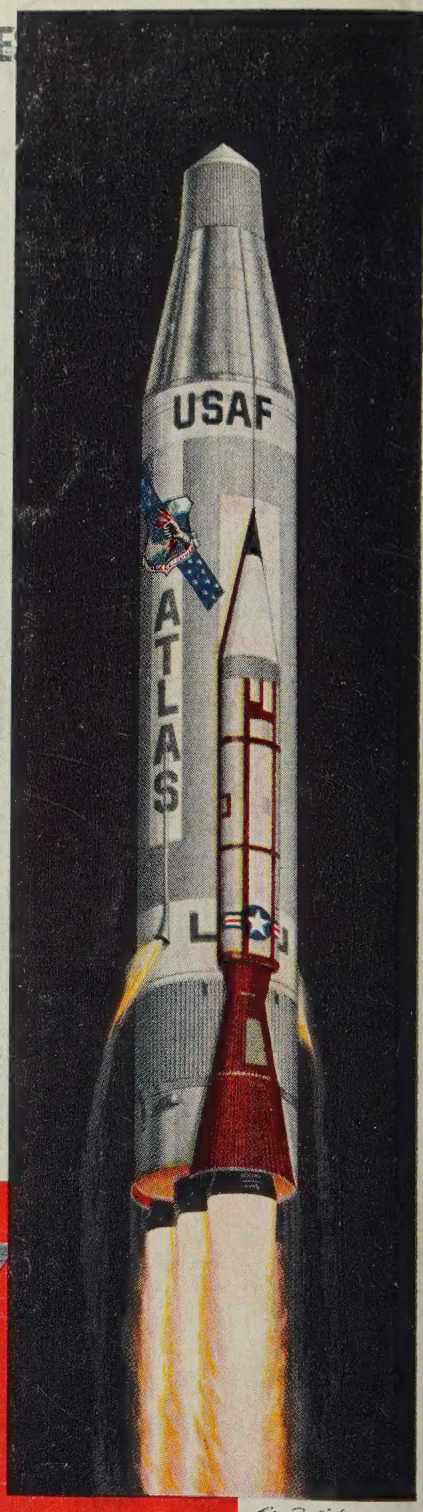
American Security



THE BENEFICIARY

Free People Everywhere





Convair's B-36 and the USAF Strategic Air Command combined to deter aggression and to prevent global conflict during the decade 1948-1958—the most critical period in all of history.

As the ultimate development of piston-engine aircraft, the *B-36 became an unequalled instrument of our national policy to maintain world peace.* The *B-36 proved to America and to the world that airpower is peace power!*

And now, to continue peace through airpower, Convair, a Division of General Dynamics, has designed and is producing the B-58 Supersonic Bomber and the Atlas ICBM—both assigned to the dedicated airmen of the Strategic Air Command who have established that *Peace is Their Profession.*

CONVAIR
A DIVISION OF **GENERAL DYNAMICS CORPORATION**